FA-137/September 1993

Minimum Standards on Structural Fire Fighting Protective Clothing and Equipment: A Guide for Fire Service Education and Procurement

Federal Emergency Management Agency
United States Fire Administration

This document was scanned from hard copy to portable document format (PDF) and edited to 99.5% accuracy. Some formatting errors not detected during the optical character recognition process may appear.

MINIMUM STANDARDS ON STRUCTURAL FIRE FIGHTING PROTECTIVE CLOTHING AND EQUIPMENT

A Guide for Fire Service Education and Procurement

Fire Fighter Health and Safety
U. S. Fire Administration
16825 South Seton Avenue
Emmitsburg, Maryland 21727

December 1992

PURPOSE OF THE GUIDE

This guide is intended to help fire fighters understand the various standards for protective clothing and equipment used in structural fire fighting. It begins with a description of the hazards encountered in structural fire fighting such as fire contact, radiant heat, physical hazards, and heat stress. An overview is presented which discusses the available standards for structural fire fighting protective clothing, including those of the National Fire Protection Association (NFPA), the Occupational Safety and Health Administration, Project FIRES, and those from international sources. Similarities and differences in each of the standards are then compared. Sections on each of the NFPA standards present a description of the types of requirements, their scope and limitations, basis for minimum performance, and a description of test methods used. The final section provides useful guidelines for specifying protective clothing in procurement actions.

The standards described in this guide are those that existed at the time it was written or those proposed for adoption in 1993.

ACKNOWLEDGEMENTS

This user guide was prepared under Federal Emergency Management Agency/U.S. Fire Administration Contract No. EMW-92-C-3698. It was prepared with the support and input of Fire Service Technical Advisory Committee that consisted of the following members:

Peter V. Ackerman, New Jersey State Director of National Volunteer Fire Council, South Plainfield, New Jersey

Glenn E. Alexander, former Fire Chief, Beavercreek Township Fire Department, Ohio

Donna H. Brehm, Battalion Officer, City of Virginia Beach Fire Department, Virginia

Douglas E. Chappell, Fire Chief, Hazel Crest Fire Department, Illinois

Robert McKeon, Chairman, National Volunteer Fire Council, Washington, DC

Gordon J. Routley, Senior Engineer, TRI/Data, Inc., Arlington, Virginia

Charles C. Soros, Battalion Chief, Seattle Fire Department, Washington

Jeffrey O. Stull, Vice President, TRI/Environmental, Inc., Austin, Texas

Dr. James H. Veghte, President, Biotherm, Inc., Beavercreek, Ohio

The Contracting Officer's Technical Representative for this effort **was Robert T. McCarthy** of the Fire Fighter Health and Safety Division for the U. S. Fire Administration.

TABLE OF CONTENTS

TABLE OF CONTENTS (CONTINUED)

INTRODUCTION

The Need for Protective Clothing/Equipment Standards

Protective Clothing for fire fighters is often selected on the basis of appearance, color, fit, or cost rather than on the basis of physiology, heat transfer characteristics, simple laws of physics, or real dollar value. Therefore, in the design of protective clothing, end users and manufacturers have generally perpetuated so-called “truths” concerning insulative properties which have been passed down within their industry and the fire service for the past century.

For example, the ventilation holes once used in both coats and pants are virtually ineffective for removing the hot, moisture laden air produced by sweating within the clothing. This is because convective pumping through these small ventilation holes permits very little moisture-laden air produced by sweating within the clothing to escape. Second, when exterior air temperatures rise above the body temperature inside a coat, the exchange of outside air with air in the clothing only accelerates the heat or caloric exchange between the wearer’s body and his clothing interior. Third, the straps of the self-contained breathing apparatus, SCBA, markedly restrict convective pumping. The end result is simply more sweating.

To ensure adequate protection, clothing and equipment must be selected on the basis of performance. Design is critical, but design alone cannot address how clothing will protect the wearer in a fire environment. Because the fire environment poses a number of hazards to the fire fighter and because the ability of clothing or equipment to protect a wearer under these circumstances is a complex question, performance criteria offer the best means for ensuring minimum protection. Standards which are comprehensive in nature, encompassing performance requirements based on qualified test methods or evaluation protocols, ease the difficulty in the selection of protective clothing and equipment for fire fighters. When selected clothing or equipment items comply with a comprehensive performance standard, the fire fighter can be assured that the item has met performance criteria which will offer a minimum level of protection. The National Fire Protection Association (NFPA) is a consensus standards organization with balanced participation from both manufacturers and fire righters. Thus, its standards have been thoroughly reviewed and are based on the best available testing technology.

HAZARDS IN STRUCTURAL, FIRE FIGHTING

The physical environment with which fire fighters contend undoubtedly contains one of the most potentially dangerous temperature extremes. Fire fighting involves strenuous work as well as a number of physical hazards. These hazards can include:

- direct flame contact,
- exposure to extreme temperatures,
- intense radiant heat,
- steam exposure,
- hazardous chemical exposure,
- electrical shock,
- exposure to UV light and ozone, and
- physical hazards.

Since fires can involve a variety of substances and environments, the presence and severity of these conditions differ from emergency to emergency. The major types of fireground injuries in 1991 were sprains, strains, cuts, and bleeding (see Table 1). Figure 1 relates the percentage of injuries to specific body regions. As these data illustrate, the hands sustain most of the injuries.

Heat and Flame Hazards

Depending upon the distance from the fire, thermal loads vary from that of the radiant heat energy of a JP-4 fuel flame front (982°C or 1800°F) to the mixture of radiant heat and convective heat typical in a smokey structural fire (93° to 315°C or 200° to 600°F). Understanding the impact of such temperatures on the working fire fighter requires knowledge about methods of heat transfer and the range of thermal conditions the fire fighter encounters. Heat may be transferred through:

- conduction
- convection, or
- thermal radiation.

Heat loss or gain by conduction normally affects only that part of a surface which is in direct contact with another surface because heat flows through the resulting continuity of surfaces. The role of heat conduction in bunker gear is usually underestimated, and is significantly increased if protective clothing is wet or compressed. Water can provide a bridge between surfaces that might not otherwise touch, increasing the chances of heat conduction by displacing insulating air between and within the layers of clothing. Even without water, compression brings surfaces together, permitting more accumulation of heat Between clothing layers. For example, when a fire fighter crawls on a hot surface his knees can be blistered because the clothing is compressed, there by permitting the conduction of heat from the surface to the skin.

Table 1. Fire Fighter Inquries by Nature of Injury and Type of Duty, 1991

Nature of Injury	Going to or from Incident		On Fireground		Nonfire Emergency		Training		Other On-Duty		Total	
	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.	No.	Pct.
Bums (fire or chemical)	30	0.6	4,960	8.9	85	0.6	495	7.5	330	1.6	5,900	5.7
Smoke or gas inhalation	50	0.9	6,270	11.2	225	1.5	80	1.2	115	0.6	6,740	6.5
Other respiratory distress	5	0.1	1,255	2.3	185	1.2	65	1.0	315	1.5	1,825	1.8
Eye Irritation	225	4.2	3,645	6.5	465	3.1	310	4.7	880	4.3	5,525	5.4
Wound, cut, bleeding, bruise	1,245	23.2	10,020	17.9	2,480	16.4	1,380	20.9	4,640	22.7	19,765	19.1
Dislocation, fracture	265	5.0	1,265	2.3	285	1.9	250	3.8	735	3.6	2,800	2.7
Heart attack or stroke	30	0.6	325	0.6	45	0.3	80	1.2	205	1.0	685	0.7
Strain, sprain, muscular pain	3,070	57.3	19,655	35.2	7,335	48.7	3,115	47.2	10,120	49.5	43,295	41.9
Thermal stress (frostbite, heat exhaustion)	55	1.0	4,630	8.3	125	0.8	425	6.4	350	1.7	5,585	5.4
Other	380	7.1	3,805	6.8	3,835	225.5	400	6.1	2,760	13.5	11,180	10.8
Total	5,355		55,830		15,065		6,600		20,450		103,300	

Source: NFPA's Survey of Fire Departments for U.S. Fire Experience (1991) appearing in NFPA Journal, November/December 1992, page 58.

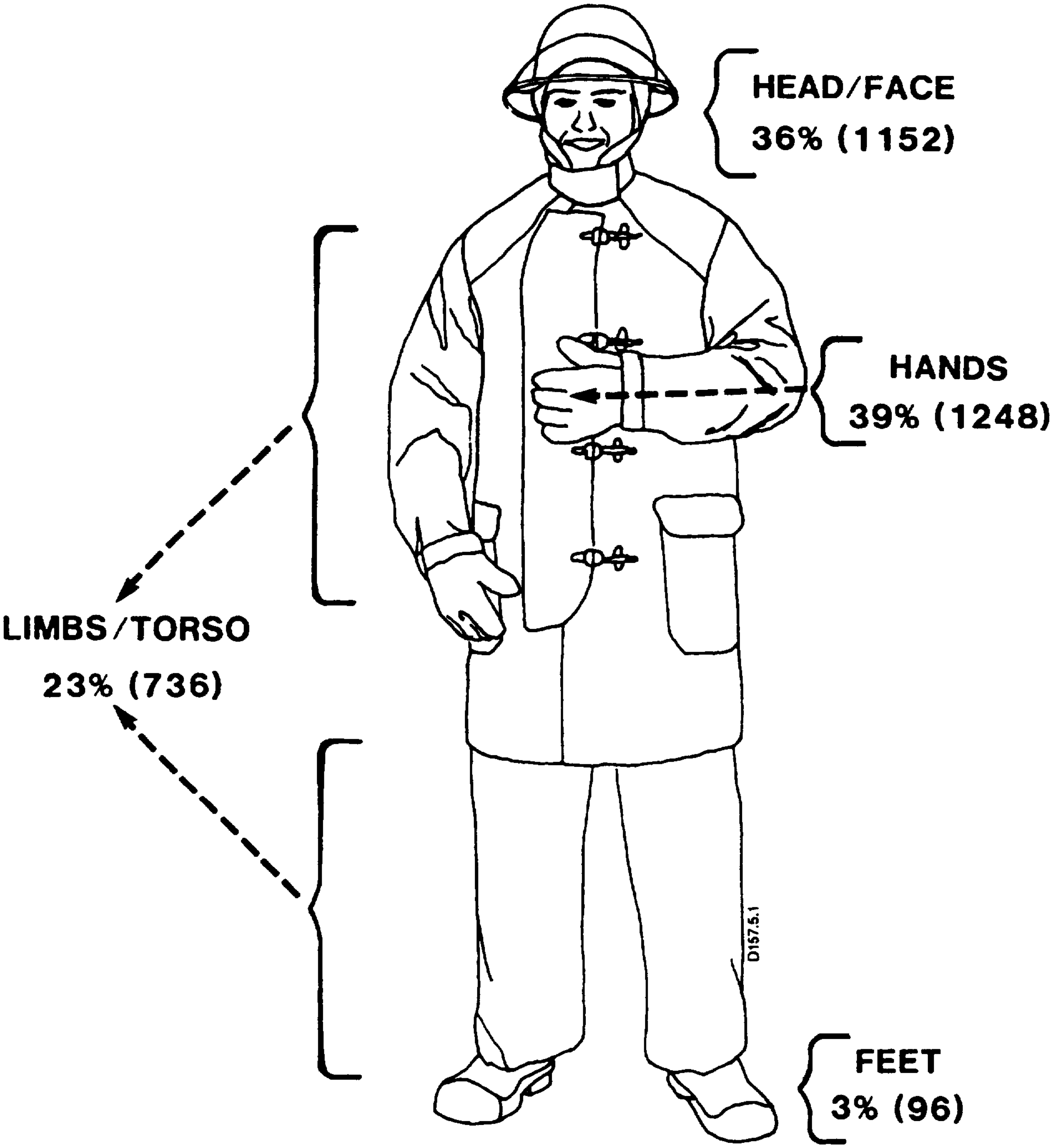

Figure 1. Burn Injury of Body Regions (percent and total number of injuries)

Heat transmission by convection is determined by the movement and the density of surrounding gases or liquids (normally air or water for fire fighters). Convection also affects the transfer of heat within layers of clothing and between these layers and the body. Spaces within the clothing or between clothing layers, if filled with air, provide convective air currents. Convective airflow within layers of clothing, and its role in the mechanics of heat transfer, is one of the most overlooked considerations in the design or selection of most protective clothing.

The most significant method of heat transfer in fire fighting is thermal radiation. Thermal radiation depends upon the temperature difference between two surfaces, the distance between two surfaces, and the reflectivity of each surface. Heat exchange by radiation does not depend on the temperature of the air between each surface, and the color of clothing does not necessarily determine reflectivity. For example, a darker color in the visible spectrum of light may actually be more reflective in the near infrared region than a white color, depending on the physical properties of the textile and dyes.

The relationship between increasing thermal radiation (expressed in Cal/cm^2 sec) and the resulting rise in air temperature (expressed in degrees Celsius and degrees Fahrenheit) is presented in Figure 2. Possible structural fire fighting situations are illustrated in this figure:

- The ***Routine*** region describes conditions where one or two objects, such as a bed or waste basket, are burning in a room. The thermal radiation and the air temperatures are virtually the same as those encountered on a hot summer day. As shown in Figure 2, ***Routine*** conditions are accompanied by a thermal radiation range of 0.025 to 0.05 Cal/cm2 sec and by air temperatures ranging from 20° to 60°C or 68° to 140°F. Fire fighting clothing is easily able to handle this thermal load.

- The ***Ordinary*** region describes temperatures encountered in fighting a more serious fire or being next to a “flash-over” room. ***Ordinary*** conditions are defined by a thermal range of 0.05 to 0.6 Cal/cm^2 sec, representing an air temperature range of 60° to 300°C or 140° to 572°F. In general, protective clothing should afford the fire fighter 10 to 20 minutes of protection under ***Ordinary*** conditions. This usually allows sufficient time to extinguish the fire or to fight the fire until his or her nominal air supply is exhausted (usually less than 30 minutes).

- The ***Emergency*** region describes conditions in a severe and unusual exposure, such as those caused inside a “flashed-over” room or next to a flame front. In ***Emergency*** conditions, the thermal load exceeds 0.6 cal/cm sec and temperatures exceed 300°C or 572°F. In such conditions, the function of fire fighters’ clothing and equipment is simply to provide the 15 to 30 seconds of protection for an escape.

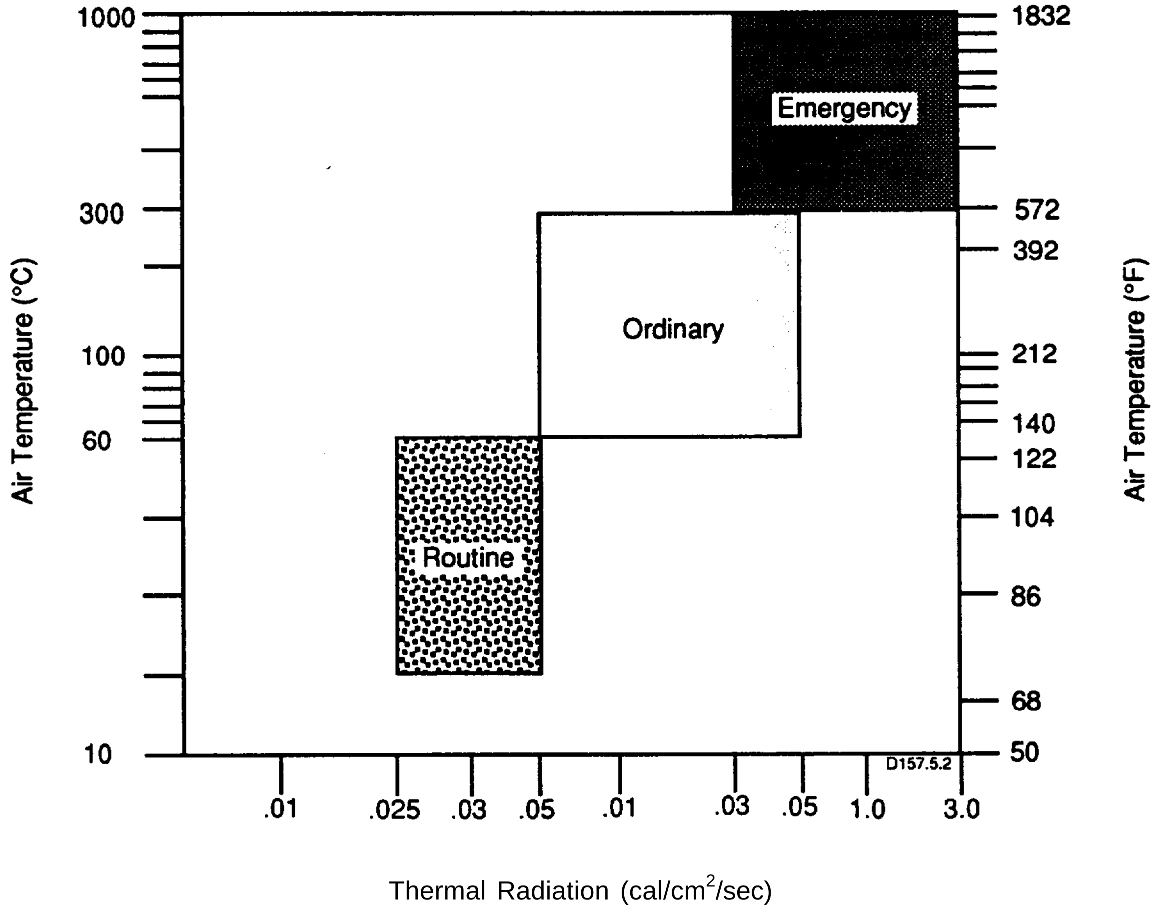

Figure 2. The Range of Thermal Conditions Faced by Fire Fighters

Clearly, protective clothing and equipment must be able to withstand a wide variety of thermal extremes. Under greater thermal loads, the outer material of turnout clothing becomes a critical factor and will only protect for a limited time.

In Figure 3, exposure to thermal radiation in cals/cm^2 sec is related to the time at which pain is felt on unprotected skin, or ***Tolerance Time,*** and the time at which unprotected skin begins to blister, or ***Blister Time*** (Stolle, 1968). As indicated, bums are both time and temperature dependent. The higher the skin temperature, the shorter the time required to blister or bum. Therefore, as skin temperatures exceed 131°F, there is no absolute level of heat at which the skin will begin to bum. In addition, prolonged or repeated high thermal exposures will gradually increase clothing temperatures. This can cause bums even after the fire fighter is no longer exposed to high ambient temperatures.

An ***Emergency*** condition exposure of 0.5 cal/cm^2 sec directly to bare skin results in pain after 1.4 seconds (tolerance time) and reversible injury or blistering of the skin after 3.4 seconds (blister time). If the exposure is raised to 1.0 cal/cm^2 sec, the time to blister is reduced to 1.3 seconds. Further destruction from such intense heat occurs rapidly thereafter because 50% of body tissue is within 1 inch of the body’s surface.

By relating the data of Figure 3 to Figure 2, it is possible to determine the amount of protection which fire fighters require under ordinary fire fighting conditions. An exposure of up to 0.3 cals/cm^2 sec will not be painful to exposed skin surfaces for 3 to 4 seconds. While clothing will protect a fire fighter from thermal injury for a much longer period of time, other physiological limitations such as air supply limit safe working conditions to a maximum of 20 to 30 minutes.

An alternative thermal classification of structural fires was developed by the International Association of Fire Fighters (IAFF) under Project FIRES. As above, fires can be distinguished by their temperature and rate of heat output. In addition, each class of fire can be associated with a structural fire fighting situation and its expected average duration as listed below:

> ***Class I*** occurs in a room during overhaul. Environmental temperatures up to 100°F and thermal radiation up to 0.05 watts/cm^2 are encountered for up to 30 minutes.
>
> ***Class II*** occurs when a small fire is burning in a room. In this case, environmental temperatures from 100 to 200°F and thermal radiation from 0.050 to 0.100 watts/cm^2 are encountered up to 15 minutes.
>
> ***Class III*** exists in a room that is totally involved. Environmental temperatures from 200 to 500°F and thermal radiation from 0.100 to 0.175 watts/cm^2 are encountered up to 5 minutes.

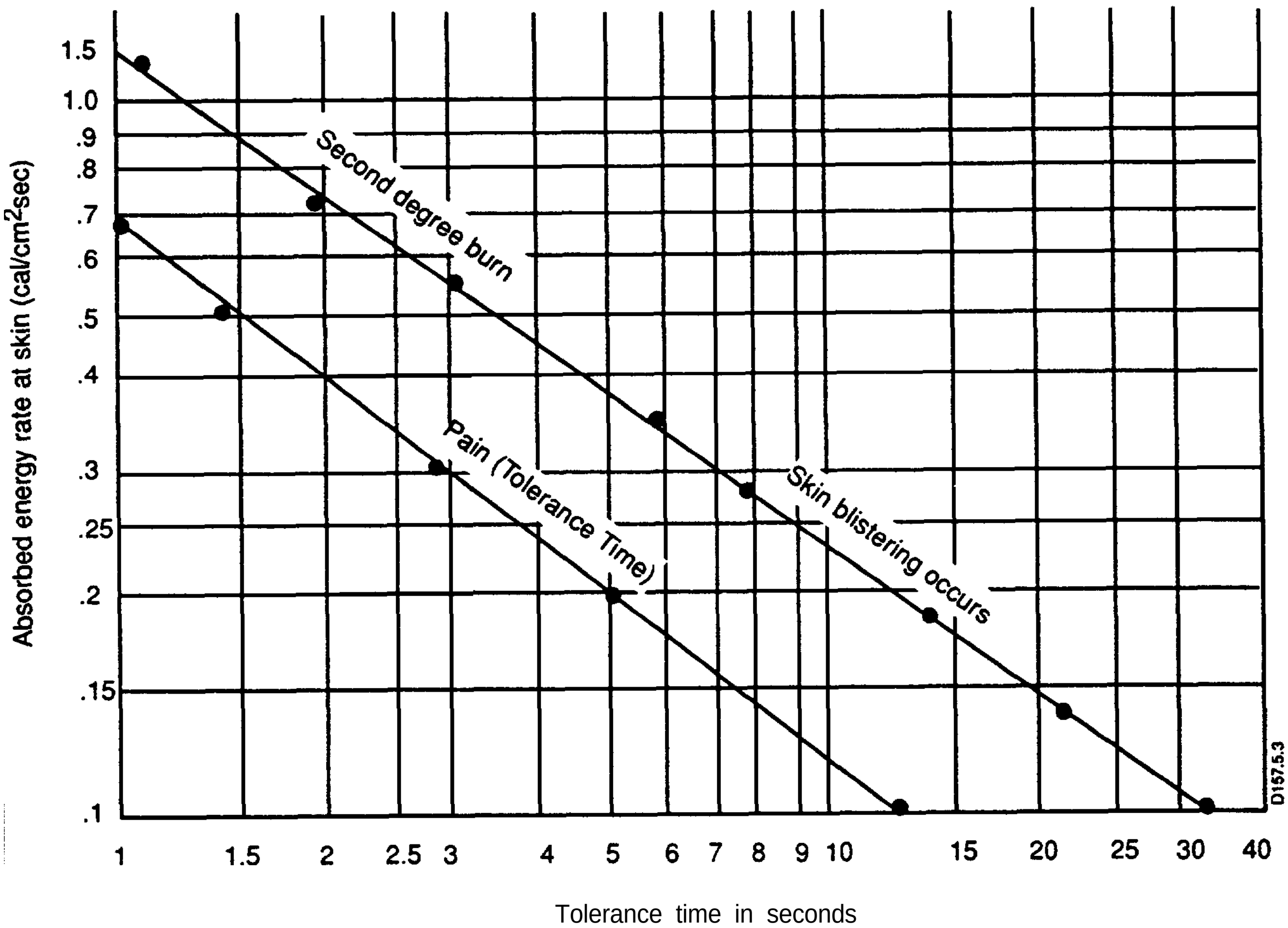

Figure 3. Human Skin Heat Tolerance

Class IV occurs during a flashover or backdraft. Environmental temperatures from 500 to 1500°F and thermal radiation from 0.175 to 4.2 watts/cm^2 are encountered up for approximately 10 seconds.

Both systems can be useful in understanding the thermal hazards associated with structural fire fighting.

Other Hazards

In addition to thermal hazards, protective clothing for use by structural fire fighters is exposed to a variety of other hazards. These include:

- ripping or tearing by sharp objects,
- penetration of steam, and
- oxygen deficient or contaminated environments.

The entire protective clothing ensemble must be designed to offer protection against all hazards anticipated with the fire environment. Furthermore, the protective nature of this clothing must be able to withstand several cycles of use and laundering. In addition, the integration of clothing and equipment items are critical areas in providing overall protection to the wearer.

As stated, fire fighters are exposed to a water specific threat, steam, which can manifest itself in two ways. First, it provides a route of heat conduction as previously described. Second, it reduces environmental insulation in cold temperature conditions. Thus, fire fighters must be protected by clothing which is layered to afford resistance to heat. This layering achieves the needed insulation for protection against both heat and cold.

Clothing for fire fighters is generally constructed of textile materials, but exposure to the various hazards in a fire may degrade the protective value of these materials. Fire fighters encounter various chemicals in their normal fire fighting activities. Exposure to oils, gasolines, and lubricants may occur around fire station vehicles. Fire fighters may also be exposed, either knowingly or unknowingly, to liquids ranging from pesticides to acids to chemical solvents during responses, These exposures, in addition to being toxic, may also degrade protective clothing material. In addition, chemical exposures may occur as chemicals in fire or smoke are adsorbed onto particles which become entrapped in clothing materials. This type of clothing contamination can lead to the chronic exposure of fire fighters to chemical hazards.

Heat Stress

Fire fighters are also exposed to physiologically demanding hazards, including stress. Fire fighting is almost always a strenuous activity with very demanding conditions. Physical work in a hot environment forces the internal body temperature to rise from its 98.6°F to 99.0°F (36° to 37.5°C) range. This rise in core temperature causes the skin and peripheral blood vessels to dilate. The thermal calories from the warmer interior of the body migrate to the normally cooler tissues near the surface of the body. As work efforts increase, the heart beats faster in an attempt to dissipate the increased metabolically generated heat, and due to the increased circulation requirements to furnish oxygen to working muscles. If the normal sweating process stops, or if the sweat is not evaporated for any reason, the body's core temperature can rise to 103.4°F or 40°C. Such hazards can be caused by "impermeable" protective clothing or by high surrounding humidity. Medical difficulties, including heat stress, are imminent under these conditions. For older persons, heart rates can increase to dangerous levels.

AN OVERVIEW OF DIFFERENT STANDARDS AND SPECIFICATIONS

Over the past decade, the protective clothing industry in the United States has undergone a number of changes in the way products are developed and sold. New materials have been identified, more manufacturers are now involved, and both governmental and other standards have created new directions within the industry. At the same time, the number of applications requiring protective clothing has expanded. Protective clothing and equipment are now used in several situations involving potential contract with hazards, although they were never used in these situations in the past. In addition, many wearers of protective clothing have an increased level of understanding of protective clothing, and therefore the selection and purchase of these products now undergo closer and more sophisticated examination of product performance. This effect has produced a wider variety of products with diverse levels of performance and capability and a common terminology relative to clothing performance now proliferates the industry. Though a number of driving forces are responsible for these changes in the protective clothing industry, one of the primary reasons for its rapid growth can be traced to the introduction of new performance standards.

The General Role of Standards

Types of criteria. In general, there are three types of criteria which can be applied in standards for protective clothing:

- documentation,
- performance, and
- design.

Documentation standards require manufacturers and testing laboratories to perform specific tests on products and to report certain results of those tests to users. These standards may also require manufacturers to provide certain product information to users such as a complete description of the materials used to manufacture a garment. A performance standard requires that a specific product property or characteristic be measured or tested. It also sets a required level of performance for that product. For example, a protective garment may be required to possess a minimum tear resistance value. These standards are also referred to a minimum performance requirements because they require that a product must attain a minimum level of performance. Third party involvement in performance standards provides reproducible results regardless of who does the testing. The most rigorous standards are design-oriented. Design standards specify the exact way in which the manufacturer must construct a particular product. Many military specifications are written this way in the United States. Design standards are generally avoided because they are restrictive, as they do not permit manufacturers any latitude to create innovative designs for their products.

Uses for standards. Both the end user and the manufacturer receive benefits and advantages from product standards. These include:

- minimum performance for improvement of protection and safety,
- set goals for new product development or improvement,
- provision for simpler selection and purchasing decisions,
- limiting liability for the manufacturer and end users, and
- an allowance for comparison of product performance.

In essence, standards define the protection that should be provided by a specific item of protective clothing or equipment. Manufacturers can design clothing and equipment in a variety of ways to meet these requirements. Standards, therefore, allow the manufacturers to judge whether or not they have an acceptable product and indicate where improvements are needed. This benefits the user by eliminating the need for users to develop elaborate specifications on their own. Thus, users can rely on the existing standards for procurement specifications, making it easier to select and purchase protective clothing and equipment. In addition, because standards require the same types of tests and evaluations, it is easier to compare various products because test information is generated and reported in the same manner.

Key standards development organizations. A number of domestic and international organizations are involved in setting standards. They represent the government, private interests, and consensus groups. There are two key consensus standards organization which develop standards relating to fire fighter protective clothing and equipment in the United states:

- the National Fire Protection Association (NFPA) Technical Committee on Fire Service Protective Clothing and Equipment, and

- the American Society for Testing and Materials (ASTM) F23 Committee on Protective Clothing.

The NFPA has been the principal standards organization for the fire service because it operates a technical committee specifically for fire fighter protective clothing and equipment. Its standards are comprehensive in nature as they apply to the whole item of clothing or equipment. Performance criteria are provided for various components used in the manufacture of a product as well as for the finished product. These standards also require independent third party certification, and listing/follow-up testing programs are required to ensure continued manufacturer compliance.

The ASTM F23 committee addresses standards on a broad range of protective clothing. In the past, the Committee principally focused on protective clothing intended to protect workers from chemical hazards or from molten metal splashes (within the metal foundry industry). Nevertheless, its scope is constantly expanding to include other types of protective clothing. A recent reorganization of the committee expanded the scope of one subcommittee from molten metals to all thermal hazards. In addition, F23 has separate subcommittees on physical hazards, ensemble performance, and human factors which define other performance areas regarding fire fighter protective clothing. Unlike the NFPA, the ASTM primarily engages in developing standards for test methods, guides, and practices. These standards define specific ways of measuring material, clothing, or equipment performance. Thus, ASTM standards are often used or cited within NFPA performance specifications. The two standards organizations are therefore complementary in their approach to creating overall standards for protective clothing and equipment.

Other organizations have also developed standards for fire fighter protective clothing and equipment. Among these are:

- the Federal government,
- the United States Fire Administration/International Association of Fire Fighters supported Project FIRES™ effort, and
- international groups, primarily the International Standards Organization (ISO) and the Committee European Normalization (CEN).

National Fire Protection Association (NFPA)

Description of organization and role. Protective clothing standards begin at the subcommittee level and proceed through a minimum approval process of 24 months before adoption (see Figure 4). The standard then proceeds to the parent technical committee for review and approval. To advance at both the subcommittee and technical committee levels, the standard must receive a two-thirds vote majority. Once the standard is approved at the technical committee level, the NFPA publishes the standard in its bi-annual Technical Committee Reports (TCR) and solicits public comments on proposed or revised standards. The technical committee must address all public comments rendered, and any changes to the standard are documented in the NFPA's Technical Committee Documentation. A standard is then brought before the NFPA membership for a final vote before promulgation as an NFPA Standard. The entire process can take anywhere from 2 to 6 years.

NFPA standards for structural fire fighting. Standards have been developed for a number of other protective clothing and equipment items that form the overall ensemble worn in structural fire fighting. The current standards include:

- protective coat, trousers, and hood (NFPA 1971),
- helmet (NFPA 1972),
- protective gloves (NFPA 1973),
- protective boots (NFPA 1974),
- station work uniform (NFPA 1975),
- self contained breathing apparatus (NFPA 1981), and the
- Personal Alert Safety System (PASS, NFPA 1982).

Advances in clothing and material technology, coupled with the development of testing protocols to measure clothing or equipment performance, have resulted in comprehensive performance criteria for each of the above items. Some standards have already undergone

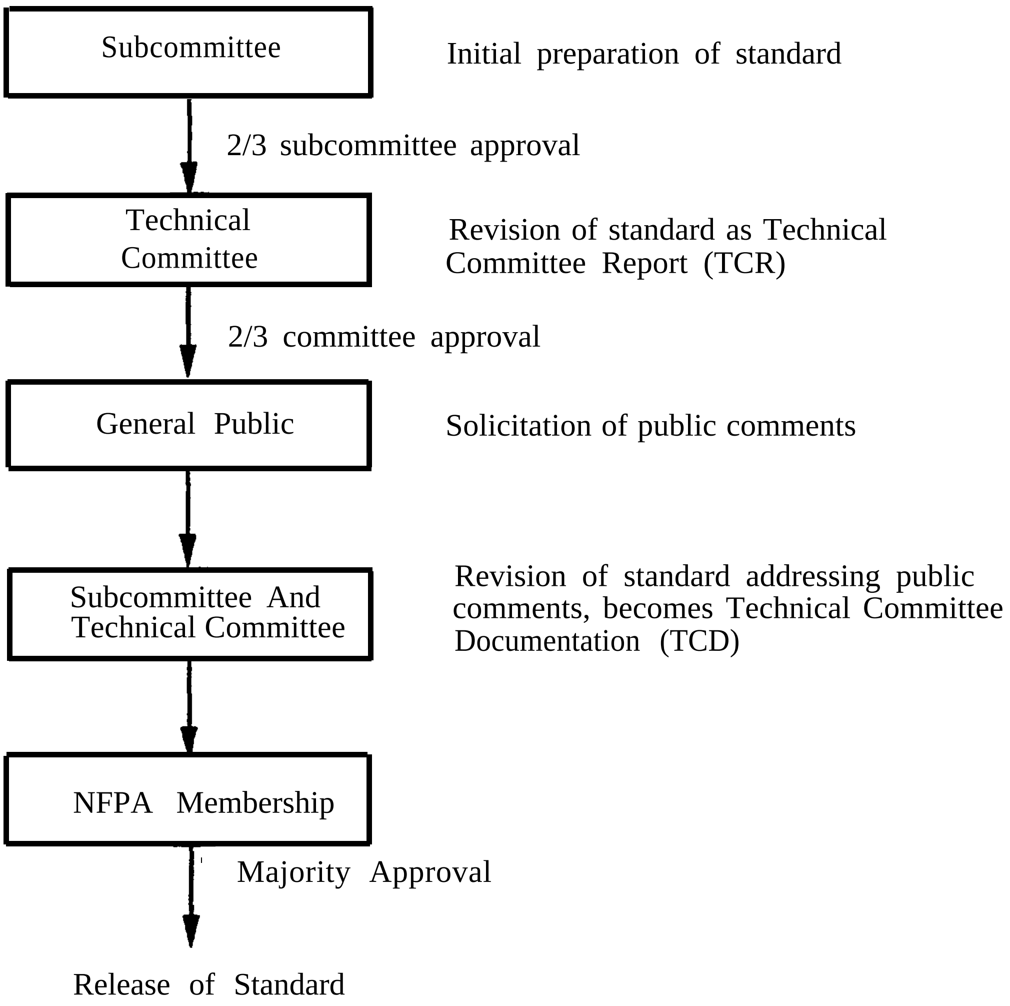

Figure 4. The NFPA standards approval process.

revisions, as required by the NFPA every five years. In each case, the purpose has been to identify performance criteria which meets the necessary minimum performance in the fire ground environment. Table 2 shows the current revision cycle for each standard.

Provisions common to all NFPA standards. Each NFPA protective clothing and equipment standard:

- sets minimum levels of performance,
- requires certification by an independent, third party organization, and
- allows labeling of compliant products.

It is important to recognize that all NFPA standards on structural fire fighting protective clothing are aimed primarily at the manufacturer. The standards represent the minimum level of protection which must be offered by a clothing or equipment item. The NFPA does not certify protective clothing or equipment. To determine whether products meet a standard, certification by an independent certifying body is required. This certification process tests sample products, and inspects manufacturers to ensure that they continue to manufacture products which meet the standard. To maintain certification, products are periodically pulled out of the manufacturer's inventory and retested, to maintain certification. Manufacturers who meet all the requirements of the standard are then entitled to label their products as compliant with the standard. This label must include the specific language in the standard, and must bear the symbol or mark of the certification organization which tested it.

Requirements in each standard. Each standard contains a set of unique requirements which govern product documentation, design, and performance. A comparison of these requirements is provided in Table 3.

User recommendations. Each standard provides advice on the use of protective clothing or equipment, but fire fighters should consult with NFPA 1500, ***Standard on Fire Department Occupational Safety and Health Program,*** for specific guidelines on the use **of** protective clothing and equipment.

Other NFPA Standards for Fire Fighting. In addition to the standards for structural fire fighting, NFPA has prepared standards for:

- proximity fire fighting (NFPA 1976), and
- wildlands fire fighting (NFPA 1977).

Proximity fire fighting includes specialized fire fighting operations involving fires producing very high levels of conductive, convective, and radiant heat such as aircraft fires, bulk flammable gas fires, and bulk flammable liquid fires. Proximity fire fighting recognizes the relatively high levels of radiant heat compared to structural fires, and that fire fighting operations are conducted closed to the fire, while direct entry is not made. In its current edition, NFPA 1976 provides requirements for protective clothing including coats and trousers, or coveralls, and hoods. In general, these items are similar to clothing used with for structural fire fighting with the exception that the outer layer of the clothing is

Table 2. Approval/Revision Schedule for NFPA Standards

Standard	Title	Current Edition	Next Edition
NFPA 1971	Protective Clothing for Structural Fire Fighting (includes hoods)	1991	1996
NPPA 1972	Helmets for Structural Fire Fighting	1992	1997
NFPA 1973	Gloves for Structural Fire Fighting*	1988	1993
NFPA 1974	Protective Footwear for Structural Fire Fighting	1992	1997
NFPA 1975	Station/Work Uniforms**	1990	1994
NFPA 1976	Protective Clothing for Proximity Fire Fighting	1992	1997
NFPA 1977	Protective Clothing for Wildlands Fire Fighting***		1994
NFPA 1981	Self-Contained Breathing Apparatus	1992	1997
NFPA 1982	Personal Alert Safety Systems (PASS)*	1988	1993
NFPA 1983	Life Safety Rope, Harnesses and Hardware	1990	1995

* Standard undergoing final Technical Committee approval in early 1993; The next edition is discussed in this report

** Undergoing early revision before 5 year cycle expires

*** New standard

Table 3. NFPA Design and Performance Requirements for Structural Fire Fighting Protective Clothing and Equipment

Performance Requirement	NFPA 1971 Turnouts	NFPA 1972 Helmets	NFPA 1973 Gloves	NFPA 1974 Footwear	NFPA 1975 Uniforms	NFPA 1981 SCBA	NFPA 1982 PASS
Strength and Durability Requirements							
Abrasion Resistance				X			
Breaking (Tensile) Strength					O		
Burst Strength					O		
Compression Resistance				X			
Cut Resistance			X	X			
Flex Fatigue Resistance				X			
Impact Resistance		X		X			X
Ladder Shank Bend Resistance				X			
Liner Pullout Resistance			X				
Puncture Resistance		X	X	X			
Retention System Strength		X					X
Seam Strength or Efficiency	X				O		
Scratch Resistance		X				X	
Suspension System Strength		X					
Tear Resistance	X				O		
Heat and Flame Requirements							
Char Resistance	X						

Table 3. NFPA Design and Performance Requirements for Structural Fire Fighting Protective Clothing and Equipment (Continued)

Performance Requirement	NFPA 1971 Turnouts	NFPA 1972 Helmets	NFPA 1973 Gloves	NFPA 1974 Footwear	NFPA 1975 Uniforms	NFPA 1981 SCBA	NFPA 1982 PASS
Heat and Flame Requirements (Continued)							
Conductive Heat Resistance			X	X			
Flame Resistance	X	X	X	X	X	X	
Heat (Oven) Resistance	X	X	X	X	X	X	X
Radiant Heat Resistance				X			
Thermal Protective Performance	X	X	X				
Thermal Shrinkage Resistance	X		X				
Thread Heat/Melting Resistance	X				X	X	
Environmental Requirements							
Biopenetration Resistance			X				
Chemical Penetration Resistance			X	O			
Colorfastness					O		
Corrosion Resistance	X			X		X	X
Electrical Insulation or Resistance		X		X			
Electronic Temperature Stress							X
Environmental Temperature Performance						X	
Lightfastness					O		

Table 3. NFPA Design and Performance Requirements for Structural Fire Fighting Protective Clothing and Equipment (Continued)

Performance Requirement	NFPA 1971 Turnouts	NFPA 1972 Helmets	NFPA 1973 Gloves	NFPA 1974 Footwear	NFPA 1975 Uniforms	NFPA 1981 SCBA	NFPA 1982 PASS
Environmental Requirements (Continued)							
Particulate Resistance						X	
Vibration or Shock Resistance						X	X
Water Absorption	X						
Water Drainage							X
Water Penetration Resistance	X		X	X			X
Other Material/Component Requirements							
Cleaning/Laundering Shrinkage Resistance	X				O		
Faceshield Light Transmission		X					
Fabric Weight					O		
Hardware Finish Quality	X						
Label Durability/Legibility		X	X	X	X		X
Total Heat Loss (Insulation Comfort)	O						
Trim Luminous Intensity	X	X					
Overall Product Requirements							
Air Flow Performance						X	
Communications Performance						X	

Table 3. NFPA Design and Performance Requirements for Structural Fire Fighting Protective Clothing and Equipment (Continued)

Performance Requirement	NFPA 1971 Turnouts	NFPA 1972 Helmets	NFPA 1973 Gloves	NFPA 1974 Footwear	NFPA 1975 Uniforms	NFPA 1981 SCBA	NFPA 1982 PASS
Overall Product Requirements (Continued)							
Dexterity			X				
Grip			X				
Heat and Flame Resistance						X	X
Sound Pressure Level							X
Sizing			X	X			
Water-Tight Integrity			X				

Legend: X - Mandatory requirement
O - Optional requirement

aluminized to reflect the expected levels of high radiant heat. No specific requirements have yet been developed for gloves, footwear, or equipment for proximity fire fighting.

Wildlands fire fighting is defined as activities of fire suppression and property conservation in vegetation (e.g., grassy fields or forests) that is not within structures, but that is involved in a fire situation. NFPA 1977 addresses requirements for protective garments, gloves, footwear, helmets, and shelters used in wildlands fire fighting. Clothing meeting these requirements are primarily single layer garments, thick work gloves, leather boots, and hard hats.

Other NFPA Standards on Protective Clothing and Equipment. For hazards other than fire fighting, the NFPA has established standards for protective clothing and equipment used in hazardous materials response and emergency medical operations. Three standards exist for hazardous material responses. These include:

- NFPA 1991, Standard on Vapor-Protective Suits for Hazardous Chemical Emergencies;

- NFPA 1992, Standard on Liquid Splash-Protective Suits for Hazardous Chemical Emergencies; and

- NFPA 1993, Standard on Support Function Protective Garments for Hazardous Chemical Operations.

The first two standards establish performance requirements for whole clothing ensembles used in the “hot zone” of hazardous materials incidents. The third standard provides criteria and test methods for garments used in support functions during the hazardous material incident such as decontamination, remedial clean up, and training.

A new standard has been promulgated by the NFPA to address protection of fire fighters and other first responders during emergency medical operations. This standard, NFPA 1999, provides requirements for emergency medical protective garments, gloves, and facewear.

One other standard of importance to fire fighters is NFPA 1983, Standard on Life Safety Rope, Harnesses, and Hardware. This standard provides specifications for rope used in rescue and other fire fighting applications as well as harness for accent or descent and related hardware.

National Fire Protection Association (NFPA) standards can be obtained from:

National Fire Protection Association
1 Battery March Park
Quincy, MA 02269

or by calling 617-770-3000.

Occupational Safety and Health Administration (OSHA)

The U.S. Occupational Safety and Health Administration (OSHA) has issued standards on fire protection in 29 Code of Federal Regulations (CFR) 1910. OSHA has specifically addressed protective clothing requirements for interior (structural) fires in its promulgation of 29 CFR 1910.156, Fire Brigades on September 12, 1980. These requirements were based on the 1981 Edition of NFPA 1971. However, OSHA allowed certain modifications that included:

- permitting discoloration of the outer shell material in the heat resistance test;
- substituting an outer shell tear strength requirement of 8.0 pounds for the 22.0 pound requirement in NFPA 1971; and
- allowing variations in garment colorfastness, shrinkage, and water absorption following washing in accordance with manufacturer's instructions.

29 CFR 1910.156 also sets specific requirements for:

- foot and leg protection,
- hand protection,
- head, eye, and face protection, and
- respiratory devices.

Since the effective date of the OSHA standard, NFPA 1971 has undergone extensive changes in two new editions. In addition, NFPA has developed separate standards for footwear, gloves, helmets, and SCBA. The requirements of these standard differ significantly from OSHA requirements. OSHA requirements have not been updated to reflect these changes. However, OSHA inspectors will accept clothing that meets the existing NFPA standards at the time of inspection.

The OSHA standard is only applicable for public sector fire fighters in certain states. In lieu of federal OSHA enforcement of health and safety standard, a state may opt to implement their own enforcement program providing federal OSHA has approved their state safety and health plan. A copy of these regulations may be obtained from:

Superintendent of Documents
U.S. Government Printing Office
Washington, DC 20402
(202) 512-1991

California State Occupational Safety and Health Standards Board (CALOSHA)

California's Safety and Health Standards Board has adopted its own set of requirements addressing protection of fire fighters during structural fires. These requirements are set in Title 8 of the California Administrative Code, Article 10.1 (1985). Like the Federal Occupational Safety and Health Administration, CALOSHA cites the 1981 edition of NFPA 1971, but includes other requirements for various clothing and equipment items. Requirements are organized into the following sections:

- head protection;
- ear and neck protection;
- eye and face protection;
- body protection;
- hand and wrist protection;
- foot and ankle protection; and
- respiratory protection.

Requirements for Personal Alert Safety System (PASS) devices are also provided. A section is also provided on wildlands fire fighting protection. In most cases, these requirements are similar but generally less in scope than those imposed by Federal OSHA. For example, CALOSHA provides requirements for hoods and wristlets, while Federal OSHA does not. CALOSHA requirements are also less comprehensive than NPPA performance criteria.

A copy of these regulations may be obtained from:

Occupational Safety and Health Standards Board
1006 Fourth Street
Sacramento, CA 95814
(9 16) 322-3640

Project FIRES™ Specifications

Based on a request from the International Association of Fire Fighters (IAFF), the U.S. Fire Administration (USFA) in conjunction with the National Aeronautics and Space Administration (NASA) undertook Project FIRES in 1976. Project FIRES stands for project on Firefighters Integrated Response Equipment System. The objective of this project was to design, fabricate, test, and evaluate an integrated protective clothing ensemble for fire fighters which would address a number of limitations existing for personal protection at the time. Grumman Aerospace was first contracted to perform these tasks, under the direction of the USFA (then called the National Fire Prevention and Control Administration), in cooperation with a User Requirements and Technical Advisory Committee made up of fire service representatives. Their study defined the hazard of the structural fire fighting environment. They next developed a series of prototypes to demonstrate advances in material and clothing technology which could be integrated in to a fire fighting ensemble. A series of field tests were performed and the prototype clothing evaluated. The IAFF then took over the study and addressed improvements in the ensemble to overcome limitations identified during the field evaluations. It worked with specific clothing and equipment manufacturers to address each problem. The IAFF also contracted outside laboratories to measure various clothing properties. Among these were thermal protective performance and heat retention. New materials were selected and prototypes redesigned for a final set of field testing. Prototypes were evaluated in a number of field tests. Project FIRES prototype and field evaluation efforts were directed for the improvement of:

- protective coat and trousers,
- hood,
- helmet,

- gloves,
- protective footwear, and
- flashlights.

At the conclusion of Project FIRES in 1985, final model performance and design criteria were established for protective coat and trousers, while a design specification was developed for protective gloves. Work on new prototype helmets and footwear was not completed, but specific approaches were identified to overcome problems with current clothing. No specifications for helmets or footwear were established. A limited effort resulted in the development of an advanced fire fighter flashlight.

Many of these Project FIRES developments and specifications led to improvements in the various NFPA standards. For example, the adoption of the Thermal Protective Performance (TPP) test in NFPA 1971.

Copies of the Project FIRES Final Report and model specifications can be obtained by writing to:

International Association of Fire Fighters
Occupational Health and Safety
1750 New York Avenue
Washington, DC 20006

or call 202-737-8484.

Canadian General Standards Board

As a counterpart to U.S. standards making process, the Canadian General Standards Board governs the development of standards for Canada. In the area of fire fighting, this organization has produced a standard on fire fighter protective clothing for protection against heat and flame (CAN/CGSB-155.1-M88). They have also developed a series of tests for measuring clothing performance to various hazards. For example, they have their own version of a test for measuring material flame resistance (CAN/CGSB-4.2 - No. 27.4/ISO 6940-1984). Many of the Canadian test methods and the requirements in the fire fighter protective clothing standard are very similar to the relevant NFPA or ASTM standards. Some requirements are identical the NFPA requirements.

A copy of CAN/CGSB-155.1-M88 and other Canadian standards may be obtained from:

Canadian General Standards Board
Sales Unit; 15th Floor
222 Queen Street
Ottawa, Ontario, Canada KlA 1G6

or by calling 613-941-8709.

International Standards Organizations

As in the United States, other countries have private or government-based organizations which are responsible for setting standards on fire fighter protective clothing. The most important organizations are the:

- International Standardization Organization (ISO); and
- the Committee for European Normalization (CEN).

IS0 is a standards organization with participating nations from all over the world. It are a consensus body much like ASTM and NFPA in the U.S. Each participating nation has an equal voice in preparing standards. Relative to fire fighting, this group has produced a number of test methods and terminology but has not established comprehensive standards such as those of the NFPA. Until recently, the United States had few or no representatives to ISO. ASTM Committee F23 on Protective Clothing is the official representative to ISO.

CEN is a relatively new standards organization which was formed to create standards for the upcoming European Community. The objective is to create a common market for all european countries by eliminating trade barriers and using common standards. Starting in 1989, CEN has the goal of finishing most of its standards by the end of 1992. It has established specific standards for testing fire fighter protective clothing and provides a comprehensive specification for fire fighter protective clothing (coat and trousers). A separate standard specification has been developed on glove for protection from heat and flame. These draft standards are listed below:

- ***prEN* 469 -** Protective Clothing for Fire Fighters

- ***prEN* 407 -** Protective Gloves Against Thermal Hazards

At the time this guide was prepared, these standards were still in draft form. There have been no standard prepared for fire fighter protective gloves, helmets, or boots. A specifications has been developed for self-contained breathing apparatus (EN 137), but this specification addresses basic performance areas and does provide any requirements demonstrating survivability in the structural fire fighting environment.

Copies of IS0 and CEN standards may be obtained from:

American National Standards Institute (ANSI)
11 West 42nd Street
New York, NY 10036

or by calling 212-642-4900.

Table 4 provides a comparison of requirements for all key components among the different sets of standards

Table 4. Comparison of Requirements in NFPA, OSHA, CAWSHA, Project FIRES, Canadian, and European Standards on Structural Fire Fighting Protective Clothing and Equipment

Type of Requirement	NFPA Standards	OSHA 29 CFR 1910.156	CALOSHA Title 8 Art. 10.1	Project FIRES*	CAN/CGSB -155.1-M88	CEN prEN 469; prEN 407
Protective Clothing (Coat and Trousers or Coveall and Hood)						
Three Functional Layers	X	X	X	X	X	
Permits Uniform as Liner	X					X
Means for Securing Liner	X		X		X	X
Permanently Secured Liner		X				
Positive Closures	X			X		
Minimum Liner Coverage	X	X		X	X	
Design to Minimize Sleeve Ride-Up					X	
Use of Wristlet	X			X	X	
Wristlet Collects Water in Upright Position					X	
Wristlet Material Resilient					X	
Cargo Pocket Drainage	X			X	X	
Min. Trim Color/Dimensions	X	X		X	X	
No Hardware Penetration	X			X	X	X
Composite Collar and Closure	X			X	X	
Collar Closure System					X	
Areas of Hood Head Protection	X					X
Noninterference of Hood	X					

Table 4. Comparison of Requirements in NF’PA, OSHA, CALOSHA Project FIRES, Canadian, and European Standards on Structural Fire Fighting Protective Clothing and Equipment (Continued)

Type of Requirement	NFPA Standards	OSHA 29 CFR 1910.156	CALOSHA Title 8 Art. 10.1	Project FIRES*	CAN/CGSB -155.1-MS8	CEN prEN 469; prEN 407
Protective Clothing (Coat and Trousers or Coverall and Hood) (Continued)						
Minimum Material Thickness		X				
Maximum Material Thickness				X		
Maximum Coat/Trousers Weight		X			X	
Minimum Coat/Trouser Overlap		X		X	X	
Ventilation Ports Allowed			X			
Permanent Label	X	X	X	X	X	X
Thermal Protective Performance	X			X	X	X
Chemical Penetration Resistance						X
Breathability	O			X	X	X
Seam Breaking Strength	X	X	X	X	X	
Textile Flame Resistance	X	X	X	X	X	X
Textile Thermal Shrinkage Resistance	X	X	X			X
Textile Heat Resistance	X		X	X	X	X
Textile Cleaning Shrinkage Resistance	X	X	X	X	X	X
Textile Colorfastness					X	
Outer Shell Tear Resistance	X	X	X	X	X	X

Table 4. Comparison of Requirements in NF'PA, OSHA, CALOSHA Project FIRES, Canadian, and European Standards on Structural Fire Fighting Protective Clothing and Equipment (Continued)

Type of Requirement	NFPA Standards	OSHA 29 CFR 1910.156	CALOSHA Title 8 Art. 10.1	Project FIRES*	CAN/CGSB -155.1-M88	CEN prEN 469; prEN 407
Protective Clothing (Coat and Trousers or Coverall and Hood) (Continued)						
Outer Shell Tensile Strength						X
Outer Shell Char Resistance	X					
Outer Shell Water Absorption	X			X	X	X
Moisture Barrier Tear Resistance	X	X	X	X	X	O
Moisture Barrier Water Penetration Resistance, High	X	X	X	X	X	
Moisture Barrier/Seam Water Penetration Resistance, Low	X			X	X	
Thermal and Winter Liner Tear Resistance	X	X	X	X	X	
Thread Heat (Melting) Resistance	X	X	X	X		
Coat Trim Luminous Intensity	X			X	X	
Trouser Trim Luminous Intensity	X			X	X	
Hardware Finish Quality	X			X	X	
Hardware Corrosion Resistance	X			X	X	
Hardware Heat Resistance	X					

Table 4. Comparison of Requirements in NFPA, OSHA, CALOSHA Project FIRES, Canadian, and European Standards on Structural Fire Fighting Protective Clothing and Equipment (Continued)

Type of Requirement	NFPA Standards	OSHA 29 CFR 1910.156	CALOSHA Title 8 Art. 10.1	Project FIRES*	CAN/CGSB -155.1-MS8	CEN prEN 469; prEN 407
Protective Clothing (Coat and Trousers or Coverall and Hood) (Continued)						
Wristlet/Hood Thermal Protective Performance	X					
Wristlet/Hood Flame Resistance	X		X			
Wristlet/Hood Thermal Shrinkage Resistance	X					
Wristlet/Hood Heat Resistance	X		X			
Wristlet/Hood Cleaning Shrinkage Resistance	X					
Wristlet/Hood Thread Heat Resistance	X		X			
Protective Helmet *						
No Shell Openings	X			No Standard	No Standard	No Standard
Clear Field of Vision	X					
Retention System Chin Strap	X	X				
Retention System Nape Device	X					
Faceshield Required	X		O			
Min. Trim Color/Dimensions	X	X				
Noninterfering Accessories	X					
Ear Covers Required		X				

Table 4. Comparison of Requirements in NFPA, OSHA, CALOSHA Project FIRES, Canadian, and European Standards on Structural Fire Fighting Protective Clothing and Equipment (Continued)

Type of Requirement	NFPA Standards	OSHA 29 CFR 1910.156	CALOSHA Title 8 Art. 10.1	Project FIRES*	CAN/CGSB -155.1-MS8	CEN prEN 469; prEN 407
Protective Helmet (Continued)						
Maximum Weight			X			
Top Impact--Force Transmission	X	X	X			
Top, Front, Side, and Back Impact--Acceleration	X					
Penetration (Puncture) Resistance	X	X	X			
Heat Resistance	X	X	X			
Flame Resistance	X	X	X			
Electrical Insulation	X	X	X			
Retention System Strength	X	X	X			
Suspension System Strength	X					
Ear Cover Flame Resistance	X	X	X			
Faceshield Impact Resistance	X					
Faceshield Flame Resistance	X					
Faceshield Scratch Resistance	X					
Faceshield Light Transmission	X					
Marking Retroreflectivity	X	X	X			
Label Durability	X					

Table 4. Comparison of Requirements in NFPA, OSHA, CALOSHA Project FIRES, Canadian, and European Standards on Structural Fire Fighting Protective Clothing and Equipment (Continued)

Type of Requirement	NFPA Standards	OSHA 29 CFR 1910.156	CALOSHA Title 8 Art. 10.1	Project FIRES	CAN/CGSB -155.1-M88	CEN prEN 469; prEN 407
Protective Gloves						
Minimum Glove Length	X			X	No Standard	
Minimum Wristlet	X	X		X		
Minimum Sizes	X			X		X
Thermal Protective Performance	X					X
Heat Resistance	X					X
Conductive Heat Resistance	X	X	X	X		X
Flame Resistance	X	X	X	X		X
Molten Metal Splash Resistance						X
Biopenetration Resistance	X					
Chemical Penetration Resistance	X					
Water Penetration Resistance	X					
Cut Resistance	X	X		X		
Puncture Resistance	X	X		X		X
Tear Resistance						X
Abrasion Resistance						X
Dexterity	X		X			
Grip	X		X			
Whole Glove Integrity	X					

Table 4. Comparison of Requirements in NFPA, OSHA, CALOSHA Project FIRES, Canadian, and European Standards on Structural Fire Fighting Protective Clothing and Equipment (Continued)

Type of Requirement	NFPA Standards	OSHA 29 CFR 1910.156	CALOSHA Title 8 Art. 10.1	Project FIRES*	CANKGSB -155.1-M88	C E N prEN 469; prEN 407
Protective Gloves (Continued)						
Glove Liner Pullout Resistance	X					
Product Label Legibility	X			X		
Protective Footwear						
Minimum Height	X	X	X	No Standard	No Standard	No Standard
Puncture Resistant Device	X					
Minimum Sizes	X					
No Metal Penetration	X					
Slip Resistant Sole		X	X			
Ankle Support Required			X			
Heat Resistance	X					
Metal Part Corrosion Resistance	X					
Sole/Heel Puncture Resistance	X	X	X			
Electrical Resistance	X					
Toe Impact/Compression Resistance	X	X	X			
Upper Cut Resistance	X					
Upper Puncture Resistance	X					

Table 4. Comparison of Requirements in NFPA, OSHA, CALOSHA Project FIRES, Canadian, and European Standards on Structural Fire Fighting Protective Clothing and Equipment (Continued)

Type of Requirement	NFPA Standards	OSHA 29 CFR 1910.156	CALOSHA Title 8 Art. 10.1	Project FIRES	CAN/CGSB -155.1-M88	CEN prEN 469; prEN 407
Protective Footwear (Continued)						
Flame Resistance	X					
Sole/Heel Abrasion Resistance	X					
Conductive Heat Resistance	X					
Radiant Heat Resistance	X					
Flex Fatigue Resistance	X					
Ladder Shank Bend Resistance	X					
Label Permanency	X					
Station/Work Uniforms*						
Flame Resistance	X	No Standard	No Standard	No Standard	No Standard	No Standard
Heat Resistance	X					
Thread Heat Resistance	X					
Label Legibility	X					
Open-Circuit, Self-Contained Breathing Apparatus (SCBA)						
NIOSH/MSHA Certification	X	X	X	No Standard	No Standard	
Positive Pressure	X	X	X			
Maximum Weight	X	X				
Minimum Rated Service	X	X	X			

Table 4. Comparison of Requirements in NFPA, OSHA, CALOSHA Project FIRES, Canadian, and European Standards on Structural Fire Fighting Protective Clothing and Equipment (Continued)

Type of Requirement	NFPA Standards	OSHA 29 CFR 1910.156	CALOSHA Title 8 Art. 10.1	Project FIRES*	CAN/CGSB -155.1-M88	CEN prEN 469; prEN 407
Open-Circuit, Self-Contained Breathing Apparatus (SCBA) (Continued)						
Air Flow Performance	X					
Environmental Temperature Performance	X					
Vibration Resistance	X					
Fabric Flame Resistance	X					
Fabric Heat Resistance	X					
Thread Heat Resistance	X					
Accelerated Corrosion Resistance	X					
Particulate Resistance	X					
Facepiece Lens Abrasion Resistance	X					
Communications Performance	X					
Overall Heat and Flame Resistance	X					
Personal Alert Safety System (PASS)						
Sound Pressure Level	X	No Standard	X	No Standard	No Standard	No Standard
Electronic Temperature Stress	X		X			
Corrosion Resistance	X					

Table 4. Comparison of Requirements in NFPA, OSHA, CALOSHA Project FIRES, Canadian, and European Standards on Structural Fire Fighting Protective Clothing and Equipment (Continued)

Type of Requirement	NFPA Standards	OSHA 29 CFR 1910.156	CALOSHA Title 8 Art. 10.1	Project FIRES	CAN/CGSB -155.1-MS8	CEN prEN 469; prEN 407
Personal Alert Safety System (PASS)* (Continued)						
Immersion/Leakage Resistance	X		X			
Case Integrity	X					
Shock Sensitivity	X					
Impact Resistance	X		X			
Retention System Strength	X					
Water Drainage	X					
Heat Resistance	X					
Overall Heat and Flame Resistance	X					
Battery Acid Resistance			X			
Maximum Weight			X			
Intrinsic Safety	X		X			
Product Label Durability	X					

* - Noted areas based on both model performance and design specifications

X - Mandatory requirement; O - Optional requirement

PROTECTIVE CLOTHING (NFPA 1971, 1991 Edition)

Scope and Limitations

NFPA 1971, ***Standard of Protective Clothing for Structural Fire Fighting,*** addresses rotective clothing for structural fire fighting. This clothing encompasses flame, heat, and hysical hazard protection to the torso, neck, arms, wrists, legs, and ankles. Structural fire ighting protective clothing is also intended to limit moisture penetration into the coat. Such rotection may be accomplished with a coat and trousers or with a full body coverall. nterface components, including separate hoods and sleeve attached wristlets, are also addressed.

The standard specifies a series of design and performance criteria which will provide a minimum level of protection to the fire fighter during the majority of structural fire ighting incidents. Protective clothing certified to NFPA 1971 is not intended to provide rotection for proximity, approach, or entry fire fighting. In addition, the standard does not rovide criteria or requirements which demonstrate protection against hazardous chemicals, adiological agents, or infectious agents. As with other NFPA protective clothing and quipment standards, NFPA 1971 can be used as a basis for purchase specifications. Because it is a minimum standard, all product requirements must be met or exceeded to be n compliance.

Basic Construction and Design Requirements

Protective clothing which complies with the NFPA 1971 standard is complex in ature. It includes a number of components which, in combination, provide full body rotection for the fire fighter. NFPA 1971 contains several design requirements, which pecify that:

- ***Protective clothing must be composed of at least three functional materials.*** Protective garments must consist of an outer shell, a moisture barrier, and a thermal liner. These three materials may be provided as single or multiple layers within the clothing. While meeting many of the same requirements, each material affords different types of protection to the fire fighter. For example, the moisture barrier is intended to prevent water from penetrating the clothing.

- ***A separate protective uniform may be worn inside the garment to meet the requirements of the standard.*** NFPA 1971 permits a separate uniform to be worn inside the protective garment to achieve the total protection offered by the combination of materials. Of course, this inner uniform must also comply with NFPA 1975.

- ***The garment must provide a mechanism to secure the moisture barrier and thermal liner to the outer shell.*** The materials must be held together while in use. This may be accomplished through the use of a zipper, snaps, or permanent stitching.

- ***Positive closures must be provided.*** Garments must utilize locking fasteners to provide secure and complete moisture and thermal protection. Snaps, fastener tape, hooks and dees, and zippers, and hooks and dees must all meet specific federal requirements or design criteria listed in NFPA 1971.

- ***Moisture barrier and thermal liner coverage must offer consistent protection.*** NFPA 1971 specifies the way in which internal material layers must extend within the garment(s).

- ***Cargo pockets must have a means of drainage and securing.*** Drainage provisions prevent water buildup in pockets, and secured flaps prevent clothing from being caught in machinery.

- ***Trim must be permanently attached to the garment and must meet specific dimensions.*** In order to ensure recognition of the fire fighter at night and in situations of limited visibility, NFPA 1971 specifies that a 2 inch wide trim be used. This trim, in the form of circumferential bands around the clothing, must be permanently attached and provide a minimum level of coverage on both the coat and trousers.

- ***Metal hardware must not penetrate all layers of the clothing.*** This requirement prevents the conduction of heat directly through the clothing. Clothing may be designed with hardware covered by either an inner or outer material to prevent hardware contact with the body.

- ***Protective coats must have wristlets.*** Wristlets prevent loose embers and hot gases from entering the wearer’s sleeves. Wristlets are also subjected to a separate set of performance requirements.

- ***Protective coats must have a composite collar and closure system.*** Collars and closures must meet all requirements for the standard which are met by other materials of construction.

- ***Protective hoods must provide limited protection to the head, face, and neck in areas of the body not protected by the collar, helmet, or SCBA facemask.*** NFPA addresses the protective hood as a separate piece of clothing, an interface component which protects the fire fighter where other components of the ensemble do not. This generally includes the sides and back of the head. The hood does not provide as much protection as the protective garment. Hoods are composed of knit materials which do not provide the same level of thermal insulation as garment materials.

- ***Protective hoods must not interfere with other ensemble components.*** The protective hood must be designed so that it does not interfere with the proper fit of the SCBA mask, protective coat, or protective helmet.

One possible configuration of protective clothing for structural fire fighting is presented in Figure 5.

A number of design features are not covered within NFPA 1971. Among these are:

- sizing,
- garment configuration (e.g., bib pants and short coat),
- position and location of closures, and
- type and location of options (i.e., pockets).

Types of Performance Requirements

NFPA 1971 performance requirements are divided into several categories representing distinct aspects, materials, or components of the clothing. Only a few equirements apply to the whole garment. The remainder address specific materials or components of the protective garment (see Table 5). These requirements are summarized below:

1. Finished garments are tested for:
   - Thermal protective performance of garment material composite, and
   - Breaking strength of different garment seam assemblies.

2. Textile materials used in construction of a garment (including outer shell, moisture barrier, thermal liner, collar liner, and winter liner fabrics, and other materials as specified in the particular requirement) are tested for:
   - flame resistance (also applies to trim),
   - thermal shrinkage resistance,
   - heat resistance (also applied to padding, reinforcement, interfacing, bindings, moisture barrier seal materials, and labels), and
   - cleaning shrinkage resistance.

3. Outer shell materials are specifically tested for:
   - tear strength,
   - char resistance, and
   - water absorption resistance.

4. Moisture barrier materials are specifically tested for:
   - tear resistance,
   - water penetration resistance, high pressure, and
   - water penetration resistance, low pressure (also applied to moisture barrier seams).

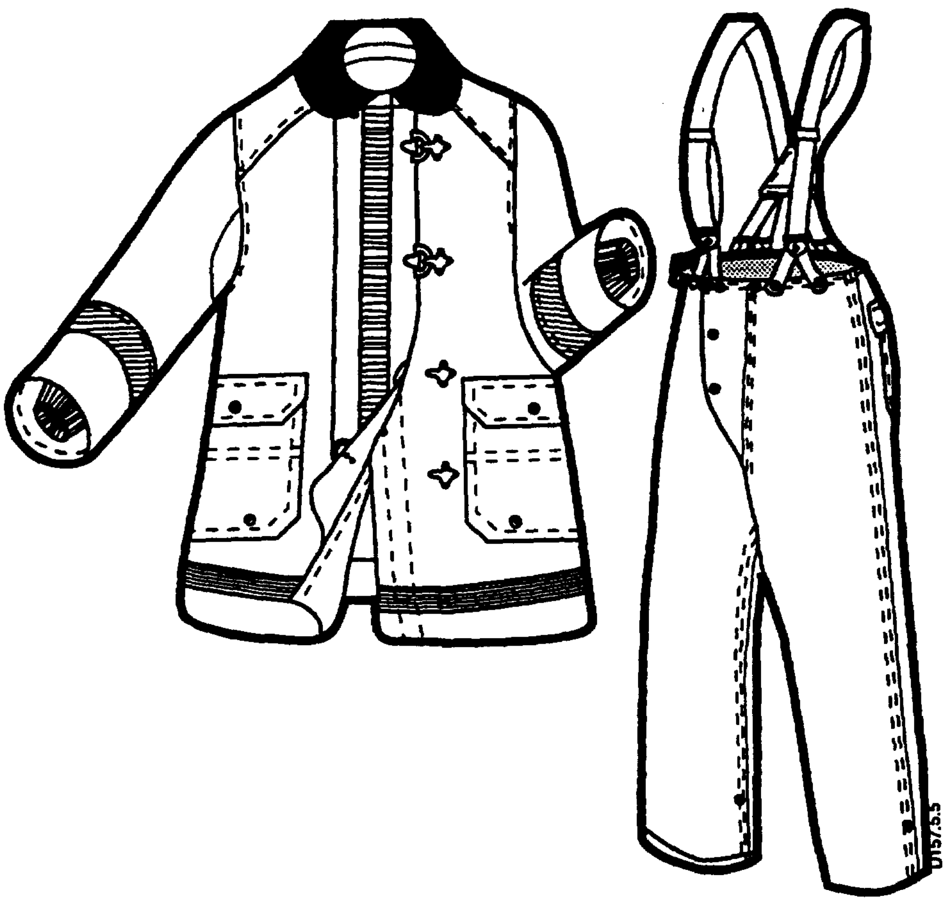

Figure 5. Typical Construction of Protective Clothing for Structural Fire Fighting

MATERIAL AND COMPONENT

TEST REQUIREMENT	Garment Composite (1)	Outer Shell	Outer Shell Seams	Moisture Barrier	Moisture Barrier Seams	Thermal Liner	Thermal Liner Seams	Winter Liner	Winter Liner Seams	Collar Liner	Reflective Trim	Miscellaneous Textile (2)	Garment Thread	Hardware	Hood Material	Hood Thread	Wristlet Material	Wristlet Thread	TEST METHOD OR SECTION NO.
Thermal Protective Performance (TPP)	4-1.1														6-1.3.1		6-2.3.1		NFPA 1971, 5-2
Breaking Strength			4-1.2		4-1.2		4-1.2		4-1.2										ASTM D1683
Flame Resistance		4-2.1		4-2.1		4-2.1		4-2.1		4-2.1	4-2.1				6-1.3.2		6-2.3.2		FTMS 191A, 5903
Thermal Shrinkage Resistance		4-2.2		4-2.2		4-2.2		4-2.2		4-2.2					6-1.3.3		6-2.3.3		NFPA 1971, 5-3
Heat Resistance		4-2.3		4-2.3		4-2.3		4-2.3		4-2.3		4-2.3			6-1.3.4		6-2.3.4		NFPA 1971, 5-4
Heat Resistance (3)					4-2.3														NFPA 1971, 5-4
Cleaning Shrinkage Resistance		4-2.4		4-2.4		4-2.4		4-2.4		4-2.4					6-1.3.5		6-2.3.5		AATCC 135,1,V,Ai
Tear Strength		4-3.1		4-4.1		4-5.1		4-6.1											NFPA 1971, 5-5
Char Resistance		4-3.2																	NFPA 1971, 5-4
Water Absorption Resistance		4-3.3																	FTMS 191A, 5504
Water Penetration Resistance, High Pressure				4-4.2															FTMS 191A, 5512
Water Penetration Resistance, Low Pressure				4-4.2	4-4.3														FTMS 191A, 5516
Thread Heat Resistance													4-7.1			6-1.3.6		6-2.3.6	FTMS 191A, 5134
Luminous Intensity											4.8								ASTM E809
Corrosion Resistance														4-9.2					ASTM B117
Heat Resistance (4)														4-9.3					NFPA 1971, 5-4

NOTES: (1) Composite includes outer shell, moisture barrier, and thermal liner
(2) Miscellaneous textiles include but are not limited to padding, reinforcements, interfacing, binding, garment labels, hanger loops, and emblems
(3) Measurement of heat resistance with assessment of dripping and ignition only
(4) Measurement of heat resistance with assessment of ignition and retention of functivility only

Table 5. Matrix of NFPA 1971 Requirements
(Section Numbers Given In Parenthesis)

5. Thermal barrier materials are specifically tested for tear resistance.

6. Winter liner materials are specifically tested for tear resistance.

7. Thread used in the construction of the garment(s) is tested for heat resistance.

8. Trim used on both coat and trousers is tested for its luminous intensity.

9. Hardware is tested for finish quality,
   - corrosion resistance, and
   - heat resistance.

10. Materials used in protective hoods are tested for:
    - thermal protective performance (TPP),
    - flame resistance,
    - thermal shrinkage resistance,
    - heat resistance,
    - cleaning shrinkage resistance, and
    - thread heat resistance.

11. Protective wristlets used on protective coats are tested for:
    - thermal protective performance (TPP),
    - flame resistance,
    - thermal shrinkage resistance,
    - heat resistance,
    - cleaning shrinkage resistance, and
    - thread heat resistance.

A complete description of each test and its application is given in Table 6.

User Information Required or Supplied

Protective clothing manufacturers are required to provide instructions and information with each garment. The instructions must cover:

- cleaning and instructions for use,
- maintenance criteria,
- methods of repair, and
- warranty information.

Manufacturers are also required to provide training materials for:

- safety considerations,
- storage conditions,
- decontamination procedures, and
- retirement considerations.

Table 6. NFPA 1971 Test Methods and Applications for Protective Clothing and Hoods

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Mandatory Tests			
Washing and Drying Procedure (5-l)	AATCC 135 (1987): Machine Cycle 1; Wash Temperature V, and Drying Procedure Ai (Section 5-l)	A sample garment and material is subjected to 5 wash/dry cycles under specific controlled conditions.	This procedure is used in conjunction with other test methods as a form of conditioning materials prior to testing. It is intended to simulate the effects of "wear and tear" on garments which may be caused by several laundering cycles.
Thermal Protective Performance, TPP (4-l.1, 6-1.3.1, and 6-2,3.1)	Method appears in Section 5-2	A composite hood or wristlet material specimen 6 ½ square, is placed on a thermal protective performance (TPP) testing device. The specimen is exposed to a combination of quartz lamps and burners which simulate both radiant and convective heat, respectively. A weighted block is placed on the sample. This block contains a thermocouple which measures the rise in temperature on the side of the material specimen opposite the side exposed to heat. The rate of the temperature rise is compared to the known skin response to heat in order to determine the amount of time required for a second degree bum. This time, multiplied by the heat exposure energy, is the TPP rating.	TPP is a measure of material insulation to heat. This means that the test measures how quickly heat is transferred from the heat outside of the material to the inside where skin may be in contact with the garment material. This test is intended to simulate the fire ground environment where fire lighters may face both convective and radiant heat. Garment composite materials must exhibit a TPP of at least 35. This is equivalent to the 17.5 seconds required to result in a second degree bum. Protective hood and wristlet materials are required to have a TPP of at least 20 (10 seconds of protection). The conditions of the TPP test are not representative of all fire fighter exposures.

Table 6. NFPA 1971 Test Methods and Applications for Protective Clothing and Hoods (Continued)

Requirement (Section No,)	Test Method Cited	Description of Test Method	Application of Test Method
Seam Breaking Strength (4-1.2)	ASTM D 1683 (1981) (Section 5-7)	A material seam specimen is placed between two grips of a tensile testing machine and pulled until it breaks.	NFPA 1971 sets different requirements for different types of seams. Major A type seams are those of the outer shell material. A rupture in this location could reduce the amount of protection provided by the garment. This could lead to exposure of the moisture barrier, the thermal barrier, the wearer's station/work uniform, other garments, or the wearer's skin. Major A seams must have a seam strength of 150 pounds of force. Major B type seams are those of the moisture barrier and thermal liner seams assemblies. A rupture in these locations could reduce the amount of protection of the garment. This could lead to the exposure of the next layer of the garment, the wearer's station/work uniform, other garments, or skin. Major B seams must have a seam strength of 75 pounds of force. Minor seams are those seams which do not fit into the Major A or Major B types of seams, whose rupture could reduce the protection of the garment by exposing the next layer of garment, the wearer's station/work uniform, other clothing, or skin. Minor seams must have a seam strength of 40 pounds of force.

Table 6. NFPA 1971 Test Methods and Applications for Protective Clothing and Hoods (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Flame resistance (4-2.1, 6-1.3.2, and 6-2.3.2)	FTMS 191A, 5903 (Section 5-2)	A 2 x 8 inch material specimen is placed in a holder that is suspended vertically over a 1.5 inch high flame. The flame is produced by a methane gas source. The material is placed in contact with the flame at the flame's midpoint for a period of 12 seconds. After exposure to the flame, the amount of time for which the specimen continues to bum (afterflame) is recorded. The length of the bum or char length is then measured by attaching a weight to the specimen and measuring the length of the tear along the bum line. Notations are recorded if any melting or dripping is observed.	This test is used to determine how easily materials ignite, and how easily they continue to bum once ignited. In order to pass NFPA 1971, textile materials used in the construction of the garment, hood and wristlet materials, cannot have an average afterflame time greater than 2 seconds, a char length greater than 4 inches, or any melting or dripping. in addition, this test is not representative of all types of flame contact to which fire fighters may be exposed.
Thermal Shrinkage Resistance (4-2.2, 6-1.3.3, and 6-2.3.3)	Method appears in Section 5-3	A 15 x 15 inch material specimen is measured and marked for size and suspended in a forced air circulating oven at 500°F for 5 minutes. Following the oven exposure, the dimensions of the material sample are compared to the original dimensions.	This test examines what happens to a material after exposure to high temperatures. Materials that shrink can reduce the fire fighter's mobility as well as the insulating qualities of the garment. In NFPA 1971, the dimensions of the garment, hood, and wristlet material must not have more than 10% thermal shrinkage.

Table 6. NFPA 1971 Test Methods and Applications for Protective Clothing and Hoods (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Heat resistance (4-2.3, 4-9.3, 6-1.3.4, and 6-2.3.4)	Method appears in Section 5-4	A 6 inch square sample is suspended in a forced air circulation oven at 500°F for 5 minutes. Following exposure, the sample is examined for evidence of melting, dripping, separation, or ignition. Samples in which this behavior is observed fail the test.	This test measures textile materials and other components used in the construction of protective garments following exposure to high heat similar to that expected in fire ground activity. It is intended to prevent materials or components which easily ignite, melt, drip, or separate from being used in the fabrication in this clothing. This test does not apply the measurement of flame resistance of trim, elastic, or hook and pile closures which are not in contact with the wearer's skin.
Cleaning shrinkage resistance (4-2.4, 6-1.3.5, and 6-2.3.5)	Method appears in Section 5-9	A material sample is subjected to 5 separate wash/dry cycles under controlld conditions. Following the cycles, the dimensions of the material sample are compared to its original dimensions.	Laundering shrinkage is a measure of the percentage a fabric constricts or shrinks after laundering. NFPA 1971 recommends that the outer shell, moisture barrier, thermal liner, collar liner, winter liner, hood, and wristlet materials shrink no more than 5%.
Tear resistance (4-3. 1, 4-4.1, 4-5.1, and 4-6.1)	Method appears in Section 5-5	A notched, trapezoidal-shaped specimen is placed between the grips of a tensile testing machine such that the material ends are parallel. The specimen is pulled until it tears completely. This test measures the force in pounds which is required to continue the tear in a notched test specimen.	Tear resistance is a measurement of the ease with which a material can be tom apart when snagged. NFPA 1971 recommends that the outer shell material have a minimum tear strength of 22 pounds. The moisture barrier, thermal liner, and winter liner materials should have a minimum tear strength of 5 pounds of force.

Table 6. NFPA 1971 Test Methods and Applications for Protective Clothing and Hoods (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Char resistance (4-3.2)	Method appears in Section 5-4	Char resistance testing is identical to heat resistance testing (requirements 4-2.3 and 4-2.9). However, the sample is specifically examined for charring. Char forms as a brittle residue when the material is exposed to high heat.	Charred materials break easily. This severely diminishes a material's capacity for providing protection. Outer shell materials must not show evidence of char.
Water penetration resistance, high pressure (4-4.2)	FTMS 191A, 5512 (Section 5-l 1)	A circular material specimen is clamped in a hydrostatic testing device. Water is pumped against the underside of the specimen at increasing pressures until the water penetrates the specimen.	This test is a measurement of the ability of a material to serve as a moisture barrier when exposed to water such as that expected in fire ground activity. Moisture barrier materials must be able to withstand moisture penetration for up to 25 psi of hydrostatic pressure.
Water penetration resistance, low pressure (4-4.2 and 44.3)	FTMS 191A, 5516 (Section 5-11)	A circular material or seam specimen is clamped on a Suter tester. A water pressure of 1 psi is applied against the underside of the material or seam specimen for a period of 5 minutes. The specimen is then examined for signs of water penetration.	This teat evaluates the barrier effectiveness of materials against water penetration. The low pressure water penetration test applies to both moisture barrier materials and seams. Water penetration may not be present in the materials or seams during the test.
Thread melting resistance (4-7.1, 6-1.3.6, 6-2.3.6)	FTMS 191A, 1534 (Section 5-12)	A small segment of thread used in protective garments, hoods, and wristlets is placed in a flask containing an organic solvent and heated. (The solvent extracts substances which would interfere with the test). Next, the extracted thread segment is put in a device which slowly heats the thread. The temperature at which the thread begins to melt is the melting temperature.	Thread used in protective garments, hoods, or wristlets must withstand temperatures of up to 500°F. If the melting temperature is less than 500°F, it fails the test. The temperature of 500°F is consistent with the heat resistance test.

Table 6. NFPA 1971 Test Methods and Applications for Protective Clothing and Hoods (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Trim Retroreflectivity (4-8.1 and 4-8.2)	ASTM E 809 (1981) (Section 5-6)	A sample of trim material is placed at a distance of 50 feet from a photometric detector. Light from a standard source is directed at the trim, and the intensity of the reflected light measured. The overall intensity of the trim is determined by multiplying the measured intensity by the area of trim on the garment.	This test provides a measurement of how easily garments can be seen at night when light reflects off of the trim. Both the jacket and the trousers must meet a specific overall intensity (coefficient of luminous intensity). However, protective jackets must meet a much higher overall intensity level than protective trousers.
Hardware finish quality (4-9.1)	Visual examination	Hardware used in the construction of protective clothing is examined for tough spots, burrs, and sharp edges.	NFPA 1971 does not allow the hardware used on protective garments to have rough spots, burrs, or sharp edges which could potentially snag or rip the garment or other clothing.
Hardware Corrosion resistance (4-9.2)	ASTM B 117 (1985) (Section 5-13)	A hardware sample is placed in a closed chamber and exposed to a 5% salt spray for a 20 hour period.	Protective clothing is exposed to water during inclement weather and during fire fighting. Therefore, garment hardware that easily corrodes may fail and render garments less protective. Hardware that exhibits signs of rust or corrosion fails the teat.
Hardware heat resistance (4-9.3)	Method appears as Section 54	The hardware heat testing is identical to heat resistance testing (requirements 4-2.3 and 4-2.9). However, samples are specifically examined for ignition and function.	Hardware must not ignite, and it must remain functional after high heat exposure.

Table 6. NFPA 1971 Test Methods and Applications for Protective Clothing and Hoods (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Optional Test			
Total heat loss	ASTM D 1518 (1985) as modified in Appendix; B	A material specimen is tested for heat transfer under two conditions. First, the specimen is placed on a hot plate which is heated to a temperature of 95°F. The environment surrounding the hot plate is controlled at a temperature of 77°F and a relative humidity of 65% . A sensor is used to measure the rate at which the heat transfers through the material. Second, the test is repeated using a different hot plate, one which releases water vapor. The heat transfer through the material is measured. Then, the results of both test conditions are used to determine the insulation value of the material.	The total heat loss test is recommended to evaluate and compare the heat transfer qualities of fabrics in relation to comfort. This test produces an efficiency measurement for evaporate heat transfer in protective clothing items. Efficiency measurements range from "0 to 1". An efficiency of '0" indicates no evaporative heat transfer, and "1" indicates total heat evaporative heat transfer. The efficiency measure for casual dress clothing ranges from 0.3 to 0.5. The efficiency measure for protective clothing generally ranges from 0.1 to 0.3.

PROTECTIVE HELMETS (NFPA 1972, 1992 Edition)

Scope and Limitations

NFPA 1972, ***Standard on Helmet for Structural Fire Fighting,*** provides design and performance criteria for helmets used in structural fire fighting. These criteria cover the need to protect the fire fighter's head from flame, heat, and physical hazards in fire ground activity and during other aspects of fire response. The helmet, in conjunction with structural fire fighting protective clothing and self contained breathing apparatus, provides protection to the face and neck. NFPA 1972 compliant helmets are not tested or evaluated for protection in other fire fighting applications such as proximity, approach, and entry. There are also no provisions for protection against biological, chemical, and radioactive hazards.

Basic Construction and Design Requirements

NFPA 1972 requires that helmets to be composed of the following elements:

- a shell,
- an energy absorbing system,
- a retention system,
- retroreflective markings,
- earcovers, and
- a faceshield.

Each component is necessary to provide the wearer with overall protection from both heat/flame and physical hazards. The shell is the hard outer material making up the bulk of the helmet. The energy absorbing system can be a material, suspension system, or combination of the two which is incorporated into the helmet to absorb impact energy. The retention system consists of a chin strap, nape (neck) pad, and suspension system that keeps the helmet in place on the head. Retroreflective markings are materials that reflect and return a relatively large portion of light close to the direction from which it was directed. Ear covers protect the ears from fire ground hazards. Although it does not provide primary eye or face protection, the faceshield furnishes limited face protection and supplements the primary eye protection of the SCBA mask. Figure 6 illustrates a typical configuration for a structural fire fighting helmet.

NFPA 1972 imposes a number of design requirements on structural fire fighting helmets. These include:

- ***There must not be openings in the shell.*** Only openings provided by the manufacturer for mounting energy absorbing, suspension, or retention systems are allowed.

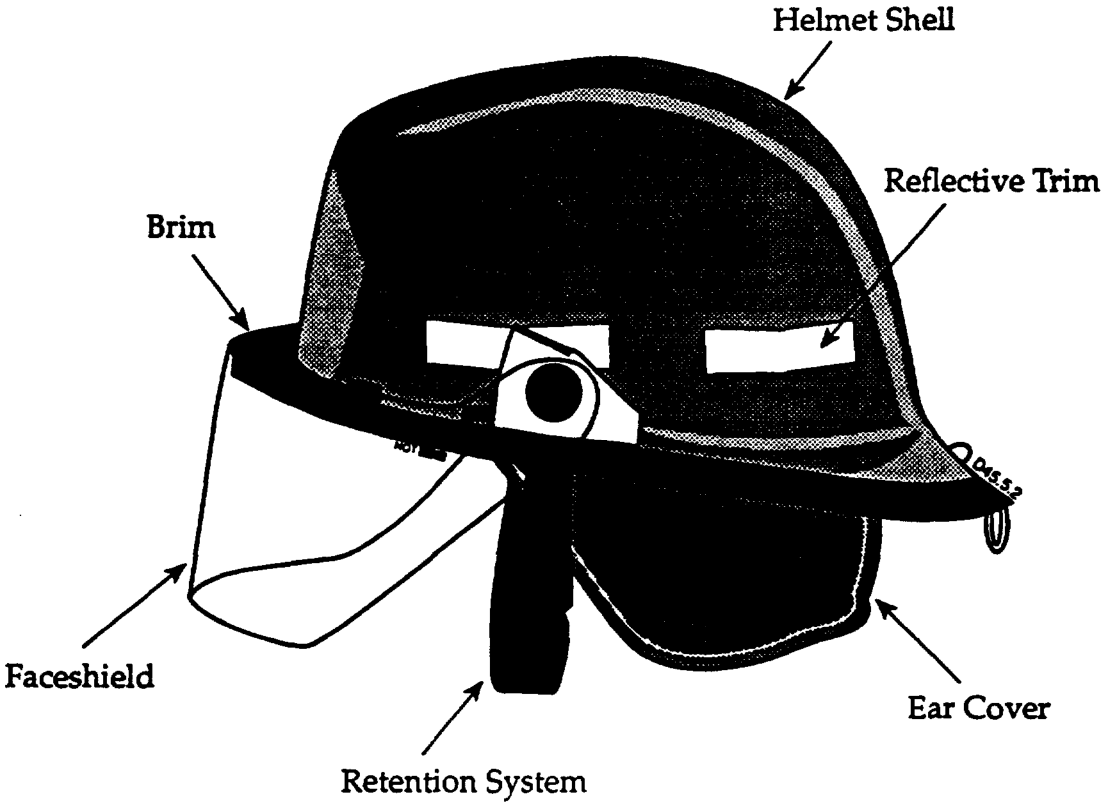

Figure 6. Typical Helmet Configuration

- ***Helmets must provide a clear field of vision.*** Peripheral vision while wearing the helmet must extend 120 degrees to either side of the centerline on the face.

- ***The retention system must include a chin strap and nape device.*** The chin strap must be at least 3/4 inch in width. The nape device is a pad that is usually affixed to the back of the helmet so that it rests on the back of the head between both ears. It assists in keeping the helmet on the head.

- ***The helmet must have a faceshield.*** The faceshield is attached to the front of the helmet and covers the face area. NFPA 1972 provides specifications on the exact area that the faceshield must cover.

- ***The helmet must have a minimum area of retroreflective trim.*** NFPA 1972 requires that 4 square inches of trim be visible upon the helmet from any given reference angle.

- ***Accessories must not interfere with helmet function and must meet all applicable requirements.*** Any accessory worn on the helmet such as emblems or lights must be subjected to the same performance tests as the rest of the helmet. They cannot contribute to the degradation of the helmet. This requirements applies only to accessories provided by the manufacturer.

The standard does not address a minimum weight or style (appearance).

Types of Performance Requirements

NFPA 1972 contains eleven requirement areas. In helmet certification, a test series consists of 10 helmets, each of which is submitted to a battery of tests. Some tests are conducted after the helmet has been conditioned to specific environmental conditions:

- *room temperature conditioning,*
- *radiant and convective heat environmental conditioning,*
- *low temperature environmental conditioning,*
- *water environmental conditioning, and*
- *faceshield elevated temperature environmental conditioning.*

Specific performance requirements include:

- *top impact force,*
- *impact acceleration,*
- *penetration resistance (from falling objects),*
- *flame resistance (two separate tests and exposures),*
- *electrical insulation (two separate tests and exposures),*
- *retention system breaking strength,*
- *suspension system pullout strength,*

- *ear cover flame resistance,*
- *faceshield impact resistance,*
- *faceshield frame resistance,*
- *faceshield scratch resistance,*
- *faceshield clarity,*
- *retroreflective trim intensity, and*
- *label durability.*

A complete description of each test and its application is provided in Table 7.

User Information Required or Supplied

Helmet manufacturers are required to provide instructions and information with each helmet which cover:

- proper use,
- cleaning,
- maintenance criteria,
- inspection frequency and details,
- painting,
- storage, and
- warranty information.

Manufacturers are also required to supply training materials for:

- safety considerations,
- decontamination procedures, and
- retirement considerations.

In addition, the appendix for the standard, Section A-2-6 provides advisory information for the user on cleaning, painting, periodic inspection, and precautions for use with structural fire fighting protective clothing. Other pertinent information and requirements are given in NFPA 1500, ***Standard on Fire Department Occupational Safety and Health Program.***

Table 7. NFPA 1972 Test Methods and Applications for Protective Helmets

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Conditioning Practices			
Room temperature environmental conditioning	Section 5-l	A sample helmet is exposed to a temperature within the range of 68-82°F for a 4 hour period.	This test simulates an ambient, non-emergency type of environmental condition.
Radiant and convective heat environmental conditioning	Section 5-2	Portions of the helmet to be tested are exposed to a radiant heat source with a surface temperature of approximately 1300°F. The samples are maintained at a distance of 3 inches until the material surface of the helmet reaches 500°F.	This test is used to simulate the high heat to which the helmet is exposed. This conditioning is used in conjunction with impact tests to determine if the helmet shell will soften when exposed to heat.
Low temperature environmental conditioning	Section 5-3	A sample helmet is exposed to a temperature of -25°F for a 4 hour period.	The test is used to simulate the low end of temperatures to which the helmet is exposed.
Water environmental conditioning	Section 5-4	A sample helmet is immersed in water at temperature within the range of 68-82°F for a 4 hour period.	This test is used to simulate the prolonged water contact to which the helmet is exposed.
Faceshield elevated temperature environmental conditioning	Section 5-5	A sample faceshield is removed from the helmet and placed on a headform. It is then exposed to a temperature of 225°F for a 20 minute period.	This test is used to separately simulate the high heat to which the faceshield is exposed.

Table 7. NFPA 1972 Test Methods and Applications for Protective Helmets (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Mandatory Requirements			
Top impact-force transmission (4-1)	Method appears in Section 5-6	A sample helmet which has been subjected to each of the environmental conditions is placed on a special headform. Then, a 7.9 pound steel dart is dropped on the top of the helmet from a distance such that a velocity of 17.9 feet per second is achieved. A load cell is attached to the headform for to measure the maximum force transmitted through the helmet by the steel dart.	This test is used to simulate a large solid object falling and striking the top of a helmet. NFPA 1972 specifies that compliant helmets cannot have a top impact force greater than 850 pounds. This requirement is similar to other head protection standards.
Top, front, side, and back impact-acceleration (4-2)	Method appears in Section 5-7	A sample helmet which has been subjected to each of the environmental conditions is placed on a special headform. Then, a 7.9 pound steel dart is dropped on selected points of the top, front, sides, and back of the helmet from a distance such that a velocity of 17.9 feet per second is achieved. An accelerometer is attached to the headform to measure the acceleration or movement of the helmet following impact.	The acceleration test is a measure of helmet movement as the result of an impact cannot exceed the force. For NFPA 1972, specific that acceleration due to impact the acceleration due to gravity for the helmet top. In addition, it cannot exceed 300 times the gravitational acceleration for the sides, front, and back of the helmet.
Penetration resistance (4-3)	Method appears in Section 5-8	A sample helmet which has been subjected to each of the described environmental conditions is placed on a special headform. A pointed 2.2 pound metal striker is dropped on two selected parts of the helmet such that a velocity of 23 feet per second is achieved. If the striker penetrates the helmet, it completes an electrical circuit which indicates that contact has been made with the headform.	The penetration resistance test is a measurement of the helmet's ability to prevent penetration or puncture from the force of falling sharp objects. The helmet must not allow any penetration.

Table 7. NFPA 1972 Test Methods and Applications for Protective Helmets (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Heat resistance (4-4)	Method appears in Section 5-16	A sample helmet is placed in a forced air circulation oven, at 500°F for 30 minutes. Following exposure, the sample is examined for evidence of melting, dripping, separation, or ignition. Samples in which this behavior is observed fail the test.	This test measures the materials and components used in the construction of protective helmets, following exposure to high heat similar to that expected in fire ground activity. It is intended to prevent materials or components which easily droop, distort, separate, melt, drip, or ignite from being used in the manufacturing of these helmets.
Flame resistance (4-5)	Method appears in Sections 5-9 and 5-10	The helmet is subjected to separate flame tests. First, portions of the sample helmet brim are exposed to a vertical bunsen burner flame fueled by methane for 15 seconds. Both the time for which the helmet material continues to bum (afterflame) and the time for which the helmet glows after burning (afterglow) are measured. Second, the top of the sample helmet is exposed to both a radiant heat source and to a bunsen burner flame at a 45 degree angle for 15 seconds. Again, both the afterflame and afterglow are measured.	This is used to determine how well the helmet shell materials will resist ignition when in contact with flame. A helmet must not exhibit visible flame or glow after the flame has been removed for 5 seconds.

Table 7. NFPA 1972 Test Methods and Applications for Protective Helmets (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Electrical insulation (4-6)	Method appears in Sections 5-12 and 5-13	Two separate electrical insulation tests are performed. First the sample helmet is inverted, filled with water, and placed in a water bath. An alternating electrical current is applied to the crown of the helmet, and current leakage is measured. Second, the sample helmet is filled with water, drained, and attached to a conductive headform with a metal bolt. An alternating current is applied to all metal parts on the helmet, and current leakage is measured.	This measures the ability of the helmet to insulate the user against electrical current as might be experienced in fire ground activity. NFPA 1972 compliant helmets must not permit any current leakage.
Retention system (4-7.1)	Method appears in Section 5-14	A sample helmet is placed on a headform outfitted with a mechanical chin structure. The chin straps are attached to the mechanical chin structure, The entire apparatus is then attached to a tensile test machine, and the straps are pulled from the helmet by the tensile test machine.	This test measures how well chin straps are secured to the helmet. Helmet straps must not break or stretch more than 0.8 inches.
Suspension system retention (4-7.2)	Method appears in Section 5-15	The helmet suspension system is attached to the helmet at several points. These "attachment points" are connected to a fixture which is attached to a tensile test machine. The "attachment points" are pulled at a steady rate to 10 pounds of force.	This test is a measure of how well the suspension system is secured within the helmet. The suspension system must remain attached to the helmet when 10 pounds of force are applied.

Table 7. NFPA 1972 Test Methods and Applications for Protective Helmets (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Ear cover flame resistance (4-8)	FTMS 191A,5903.1 (Section 5-21)	A 2 x 8 inch material specimen is placed in a holder. It is suspended vertically above a 1.5 inch high flame which is produced by a methane gas source. The material is placed in contact with the flame at its midpoint for a period of 12 seconds. Following exposure, the time during which the sample continues to burn (afterflame) is recorded. The char length is then measured by attaching a weight to the specimen and measuring the length of the tear along the bum line. A notation is made if any melting or dripping is observed.	This test measures the ease at which ear cover materials ignite and continue to bum when exposed to flame. In order to pass NFPA 1971, textile materials used in the construction of the garment, hood, and wristlet materials cannot show an average afterflame time of greater than 2 seconds and the or char length cannot be greater than 4 inches. In addition, no melting or dripping may be observed. This test is not representative of all types of flame contact to which fire fighters may be exposed.
Faceshield impact resistance (4-9. 1)	Method appears in Section 5-17	A sample helmet which has been subjected to each of the described environmental conditions (except radiant and convective heat conditioning) is placed on a special headform which is outfitted with a contact sensor in the nose region. The headform and helmet are positioned so that the faceshield is lying flat and pointing upward. An 8 - ounce steel ball, 1.5 inches in diameter, is rolled down a 40 inch guide tube toward the faceshield. If the ball forces the faceshield into contact with the sensor, an electrical circuit is completed and an indicator light comes on.	This test is used to simulate impact of a hard object directly to the faceshield and measures how well the faceshield resists deflection. NFPA 1972 does not permit deflection of the faceshield such that electrical contact is made during the test.
Faceshield flame resistance (4-9.2)	Method appears in Section 5-11	A sample helmet with faceshield is placed on a headform. A bunsen burner, fueled by methane, is placed in contact with the edge of the faceshield at a 45 degree angle for 15 seconds. Both afterflame and afterglow are measured.	This test measures how well the faceshield materials resist ignition following exposure to flame. Faceshields must not have visible signs of afterflame or afterglow 5 seconds after the flame has been removed.

Table 7. NFPA 1972 Test Methods and Applications for Protective Helmets (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Faceshield scratch resistance (4-9.3)	Method appears in Section 5-20	A faceshield material specimen is placed in an abrasion device. Small silica spheres under 4 psi of pressure are used as abradants. The abrasion device is cycled through 50 strokes, and the specimen removed and examined for evidence of scratches.	This test is a measure of the ease with which the faceshield resists scratches or abrasion expected during exposure to physical hazards. Faceshield materials must not yield more than 15 linear scratches during the test.
Faceshield light transmission (4-9.4)	ASTM D 1003 (1988) (Section 5-18)	A faceshield material specimen is placed in a spectrophotometer. The spectrophotometer directs light through the material and measures the amount of light transmitted through the sample. The amount of light transmitted is the luminous transmittance. The amount of light distorted is called haze.	This test is a measure of the ease with which the wearer will be able to see clearly through the faceshield. NFPA 1972 clear helmet faceshield must transmit 85 percent of light. The colored faceshield materials must transmit at least 43% of light. (The color of the faceshield absorbs some of the light.)
Marking retroreflectivity (4-10)	ASTM E 810 (1981) (Section 5-19)	A sample of trim material is placed 50 feet away from a photometric detector. Light from a standard source is directed toward on the trim, and the intensity of the reflected light measured.	This testing measures the visibility of helmet trim markings at a distance under reduced lighting conditions. The minimum measure of visibility for fire fighter helmets is based on acceptable measured light intensity at the test distance.
Label durability (4-l1)	Method appears in Section 5-22	A sample helmet is exposed to the environmental conditions described, and then the label is examined for legibility.	This test is a measure of label durability. Labels must remain legible following all conditioning.

PROTECTIVE GLOVES (NFPA 1973, 1993 Edition)

Scope and Limitations

NFPA 1973, ***Standard on Gloves for Structural Fire Fighting,*** provides design and performance requirements for gloves used in structural fire fighting. The standard is intended to provide the wearer with protection against flame contact and physical hazards encountered in structural fires. Gloves meeting the revised form of this standard may also provide limited protection from chemicals and infectious agents. Requirements exist in the standard which attempt to keep the hands as dry as possible during the course of fire fighting activities. NFPA 1973 compliant gloves are not tested for or certified for other forms of protection needed in proximity, approach, or entry fire fighting situations. In addition, they are not intended to provide protection from radiological hazards or for all hazardous chemicals.

Basic Construction and Design Requirements

NFPA 1973 compliant gloves must provide protection to the whole hand, including the region which extends one inch above the wrist crease. When wristlets are included as a part of gloves, they must extend at least two inches above the wrist crease. Glove materials may be a single layer or a composite of materials which meet the performance requirements of the standard (see Figure 7). Both the glove body and the wristlet materials must meet all requirements.

Manufacturers must make structural fire fighter gloves in at least five different sixes. The exact dimensions of these sizes are specified in NFPA 1973. Therefore, a particular size glove from one manufacturer should have the same dimensions as the same size glove from another manufacturer.

Types of Performance Requirements

There are fourteen different performance requirements for structural fire fighting gloves. Table 8 provides a general description of how each test is conducted as well as its application in providing fire fighter protection. The requirements are:

- *thermal protective performance (TPP),*
- *heat resistance,*
- *conductive heat resistance,*
- *flame resistance,*
- *bio-penetration resistance,*
- *chemical penetration resistance,*
- *water penetration resistance,*
- *cut resistance,*
- *puncture resistance,*

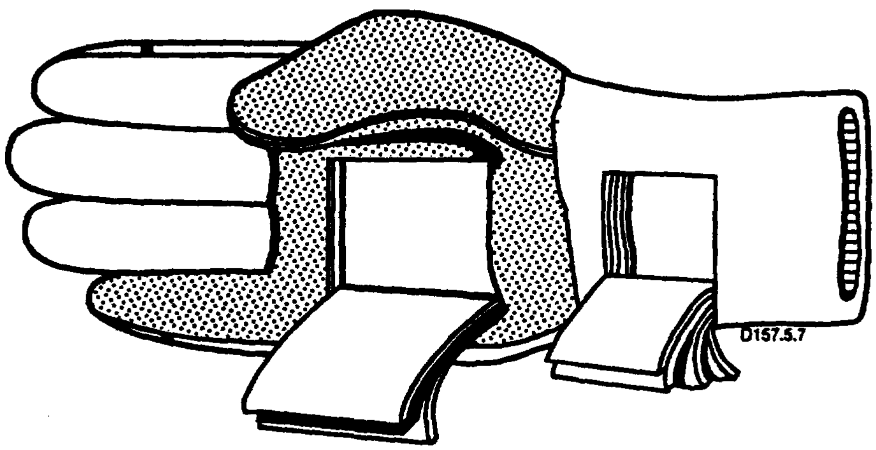

Figure 7. Typical Construction of Gloves for Structural Fire Fighting

Table 8. NFPA 1973 Test Methods and Applications for Protective Gloves

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Conditioning Practices			
Preconditioning (5-l.1)	AATCC 135, Machine Cycle 3, Wash Temperature V, and Drying Procedure Ai	A sample glove is subjected to 5 separate wash/dry cycles. The sample glove is then worn by a test subject, and is flexed into a fist 10 times in a 30 second period.	This test is designed to simulate glove use. This preconditioning step is used prior to other glove property testing.
Dry conditioning (5-l.2)	Specified in section 5-1.2	A sample glove is exposed to a temperature of 70°F and relative humidity of 65% for 24 hours.	This procedure provides a uniform conditioning practice to be used with other glove material determinations.
Wet conditioning (5-1.3)	Specified in section 5-1.3	A sample glove is immersed in water, 70°F, for 2 minutes. It is then drained and dried with blotting paper.	This procedure provides a uniform conditioning practice to be used with other glove material determinations simulating soaking as expected during fire ground activity.

Table 8. NFPA 1973 Test Methods and Applications for Protective Gloves (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Mandatory Requirements			
Thermal protective performance, TPP (4-l)	Method appears as Section 5-2	A preconditioned sample which has been subjected to both wet and dry conditioning is tested using a thermal protective performance (TPP) testing device. A 6.5 inch square sample is placed on the device. It is exposed to a combination of quartz lamps and burners which simulate radiant and convective heat, respectively. Next, a weighted block, which contains a thermocouple, is placed on the sample. The thermocouple measures the temperature rise in the material specimen on the side opposite the one receiving exposure. The rate of temperature rise is compared to the known skin response time required for a second degree bum. This time, multiplied by the exposure heat energy is the TPP rating.	Thermal protective performance (TPP) is a measure of how well a material insulates against heat. Thus, the TPP test measures the speed in which heat transfers from the outside of the material to the inside of the material which may be in contact with the wearer's skin. The test simulates the exposure to both convective and radiant heat expected in the tire ground environment. Protective glove material must exhibit a TPP of 35 or greater. This is equivalent to the 17.5 seconds required to result in a second degree bum. The conditions of the TPP test are not representative of conditions which may occur in a flashover.
Heat resistance (4-2)	Method appears as Section 5-3	A preconditioned, 4 inch square sample is suspended in a forced air circulation oven at 500°F for 15 minutes. Following exposure, the sample is examined for evidence of melting, dripping, separation, or ignition. Samples which exhibit this behavior fail the test.	This test is a measure of the reaction which occurs when glove materials and other components are exposed to the high heat expected in fire ground activity. It is intended to prevent materials or components which easily ignite from being used in the manufacturing of glove materials. The high heat exposure, 500°F for 15 minutes, is representative of conditions existing during a flashover.

Table 8. NFPA 1973 Test Methods and Applications for Protective Gloves (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Conductive heat resistance (4-3)	ASTM F 1060 (1987) (Section 5-4)	A sample glove material specimen is exposed to both wet and dry preconditioning cycles. Following exposure, the specimen is placed on a hot plate which is heated to a temperature of 532°F. A weighted thermocouple is then used to measure the temperature of the interior glove material (the side next to the wearer's skin). The rise in temperature following heat exposure is used to determine the times required for a second degree to occur and for the user to feel pain from the bum.	This test, similar to the TPP test, measures the rate of heat transfer through the glove material. However, the TPP test measures the heat transfer from radiant and convective sources, while this test measures the heat transfer from surface contact (i.e., touching a hot metal object). Glove materials must exhibit second degree bum times of greater than 10 seconds, and time to pain times greater than 6 seconds.
Flame resistance (4-4)	FTMS 191 A, 5903.1 (modified in standard as section 5-5)	A 3 x 4 inch material specimen is placed in a holder and is suspended over a flame produced by a methane gas source. Unlike traditional vertical flame tests, the specimen is bent over the flame in an "L" shape. The material is exposed to the flame at its midpoint for 12 seconds. Following exposure, the time for which the sample continues to bum (afterflame) is recorded. The char length is then measured by attaching a 5 pound weight to the specimen and measuring the length of the tear along the burn line. Notations are made if any melting or dripping is observed.	This test measures the ease with which materials ignite and continue to bum once ignited. NFPA 1975 specifies that materials cannot exhibit an average afterflame time of greater than 2 seconds or an average char length of greater than 6 inches. In addition, no melting or dripping can be observed. This requirement is less stringent for the NFPA standards which govern other protective clothing, gloves, and boots. However, this test does not represent all types of flame contact to which fire fighters may be exposed.

Table 8. NFPA 1973 Test Methods and Applications for Protective Gloves (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Bio-penetration resistance (4-5)	ASTM ES 22 (1992); Method also written in standard as Section 5-6	A 2.4 square inch material specimen is taken from the glove palm, back, and seams. The samples are placed in separate test cells. One side of the test cell is filled with a solution containing a microorganism which mimics the AIDS and hepatitis viruses. The material specimens are kept contact with the solution for one hour, of which one minute is at pressure of 2 psi. Following exposure, the opposite side of the specimen is rinsed with a different solution. It is then analyzed for the microorganism using a micro-biological technique. If microorganisms are detected, the glove fails test.	This test measures the effectiveness of glove materials as a barrier to potentially infectious agents. The glove material cannot permit any penetration of virus or it fails the test. The test was selected because it correlates well with simulated exposures to synthetic blood.
Chemical penetration resistance (4-6)	ASTM F 903 (1990) (Section 5-7)	A 2.4 square inch material specimen is taken from the glove palm, back, and seams. The samples are placed in separate test cells. One side of the test cells is tilled with the test chemical. The material specimens are kept in the test chemical for one hour, one minute of which is at a pressure of 2 psi. Following exposure, the opposite side of the specimen is visually examined to determine if the liquid chemical has penetrated the specimen. Samples which show visual signs of penetration fail the test. The test is conducted with 5 chemicals: AFFF concentrate, battery acid, gasoline, hydraulic acid, and the chlorine additive used in swimming pools.	This test evaluates the ability of the material to serve as a barrier to selected liquid chemicals. Glove materials must resist the penetration of all five chemicals for a period of one hour. (A one hour exposure would be considered a worse case scenario). Other chemicals may permeate the material and still pass this test. The chemicals selected were intended to represent the common chemicals expected in fire ground activity.

Table 8. NFPA 1973 Test Methods and Applications for Protective Gloves (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Water penetration resistance (4-7)	Method appears as Section 5-8	A 2 x 4 inch material specimen is taken from the glove body and placed in a circular test fixture for support. Water is directed into one side of the fixture at increasing pressures until the water visually penetrates the material specimen. The pressure at which the water is observed to penetrate the specimens is the water penetration resistance.	This test provides an indication of how well glove materials prevent water penetration and keep thus the wearer's hands dry. The standard requires that glove materials withstand a pressure of 4 psi for 1 minute without any detectable penetration.
Cut resistance (4-8)	Method appears as Section 5-9	Sample gloves are subjected to 5 separate wash/dry cycles and, then subjected to hand flexing and dry conditioning. A 2 x 4.5 inch test specimen is cut from the sample gloves, and placed on a specimen support holder. The specimen and holder are drawn under a weighted blade test fixture, which uses a standard razor blade. Following this process, the material specimen is examined to determine whether or not the razor blade cut through the material. If there is no cut through the weight is increased on the fixture pivot arm which holds the razor blade.	Sample materials must not cut yield to a cut through under a force of 18 pounds. This force was judged to be adequate to prevent different types of injuries occurring from sharp edged blades in the NIOSH study.

Table 8. NFPA 1973 Test Methods and Applications for Protective Gloves (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Puncture resistance (4-9)	ASTM F 1342 (1991) (Section 5-10)	A sample glove material specimen is subjected to wet and dry conditioning. It is then placed in a sample holder which is attached to a tensile testing machine. The tensile testing machine, which is outfitted with a compression cell, has a probe on the opposite end with dimensions similar to a 6 penny nail. The nail is pushed into the material sample at a fixed rate of speed, and the force required to puncture the material is measured.	Sample materials must withstand a puncture force of 13.2 pounds. This force was judged to be adequate to prevent different types of injuries from occurring due to glove punctures in the NIOSH Study.
Dexterity (4-10)	Method appears as Section 5-11	A sample glove is subjected to 5 separate wash/dry cycles and then subjected to subject hand flexing. This glove is further subjected to wet conditioning with a 2 minute immersion in 70°F water. Sample gloves arc tested for dexterity using the Bennett Hand-Tool Dexterity Test. In this test, a test subject must manipulate several bolts and nuts into a test frame. The time required to manipulate all bolts is timed. The same tests are then performed without the glove.	Test subjects wearing gloves must be able to perform the same hand operations, both bare-handed and with gloves, within a particular time frame. The time frame for tests conducted with gloves can be no greater than 140% from when compared bare-handed tests.

Table 8. NFPA 1973 Test Methods and Applications for Protective Gloves (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Grip (4-11)	Method appears as Section 5-12	A sample glove is subjected to 5 separate wash/dry cycles and then subjected to subject hand flexing. Some gloves are subjected to further wet conditioning with a 2 minute immersion in 70°F water. Other gloves are dry-conditioned by further exposure to 70°F air at 50% relative humidity. Test subjects wearing these gloves lift as much weight as possible by pulling on both a wet and a dry 3/8 inch rope. The amount of weight lifted with gloves is compared to the amount lifted without gloves.	Test subjects wearing gloves must be able to lift at least 80 percent of the weight which they can lift without gloves. The requirement is intended to provide fire fighters with gloves which will not diminish the ability to grip tools, hoses, ladders, or other items.
Whole glove integrity (4-12)	Method appears as Section 5-13	A test subject wears keep inner glove constructed of a fabric which easily displays watermarks. A sample pair of gloves is worn over the special inner glove. The test subject then immerses his/her hands in water at room temperature and flexes the gloves in a fist clenching motion every 10 seconds. After 5 five minutes, the sample glove is removed and the inner glove examined for signs of water penetration.	This test is a measure of the ability of the glove to serve as a water tight barrier. Other tests previously described apply to material samples only.
Glove liner pullout resistance (4-13)	Method appears as Section 5-14	A sample glove is preconditioned by a test subject's hand. After the hand is removed from the glove, the glove liner is examined for signs of becoming disengaged.	This test is designed to measure how well the glove liner will remain attached to the glove after repeated use. Glove liners which show evidence of disengagement or pullout fail the test.
Product label legibility (4-14)	Method appears as Section 5-15	A sample glove label which contains the required language is subjected to 5 separate wash/dry cycles. Next, the sample is subjected to repeated flexing on a human subject. The sample glove label is then examined for legibility.	This test measures the durability of glove labels. Glove labels must remain legible after repeated use. A wearer with 20-20 vision must be able to read the entire label after preconditioning or the label fails the test.

- *dexterity,*
- *grip,*
- *whole glove integrity,*
- *glove liner pullout resistance, and*
- *product label legibility.*

Many of the tests are performed after preconditioning, consisting of 5 cycles of washing and drying following by simulated glove use, wet conditioning, dry conditioning, or a combination of all three.

Many of the test methods and performance criteria in the standard were developed in a February 1976 study sponsored by the National Institute for Occupational Safety and Health (NIOSH) entitled, “The Development of Criteria for Fire Fighters’ Gloves.” This study established the need for specific areas of protection, suggested test methods, and recommended pass/fail criteria for each measured property.

User Information Required or Supplied

Protective glove manufacturers are required to provide instructions and information with each pair of gloves which will cover:

- user marking,
- storage,
- maintenance,
- frequency and details of inspection criteria for removal from service,
- other information related to glove serviceability,
- decontamination and disposal,
- cleaning and drying, including applicable warnings regarding detergents, soaps, cleaning additives, and bleaches, and
- a warning which states, “DO NOT USE GLOVES UNLESS THEY HAVE BEEN THOROUGHLY CLEANED AND DRIED”.

In addition, other pertinent information and requirements are stated in NFPA 1500, ***Standard on Fire Department Occupational Safety and Health Program.***

PROTECTIVE FOOTWEAR (NFPA 1974, 1992 Edition)

Scope and Limitations

NFPA 1974, ***Standard on Protective Footwear for Structural Fire Fighting,*** provides design and performance requirements for protective footwear or boots used in structural fire fighting. The standard is intended to provide the wearer protection against flame/heat contact and physical hazards encountered in structural fires. NFPA 1974 compliant footwear is not tested or certified for other forms of protection needed in proximity, approach, or entry fire fighting situations. In addition, it is not intended to provide protection from radiological or hazardous chemicals.

Basic Construction and Design Requirements

NFPA 1974 does not specify that one particular type of footwear is preferred over another (e.g., rubber boots versus leather boots). Rather, the standard sets a number of design and performance requirements that can be potentially met by a variety of footwear designs and constructions. NFPA 1974 states that footwear must include a sole with heel, upper with lining, insole with puncture-resistant device, and a permanently attached compression-resistant toe cap (steel toe). The puncture-resistant device is a component which reinforces the bottom of the protective footwear located between the sole with heel and insole. Figure 8 illustrates two different types of protective footwear capable of complying with the NFPA 1974 standard.

NFPA 1974 includes design requirements relative to footwear configuration and sizing. The standard requires that:

- *footwear must be at least 8 inches tall without tapering of the heel sides or rear,*
- *the puncture-resistant device must cover the entire insole area,*
- *footwear must be offered in a number of standard sizes, including halfsizes, and in two widths for both men (sizes 5-13) and women (sizes 5-10), and*
- *the construction of the boot must be such that metal parts do not penetrate from inside to outside (to limit heat conduction), and that they are not used to attach the heel or any puncture-resistant device.*

There is no minimum weight requirement. Also, the responsible subcommittee has yet to develop a requirement addressing appropriate ankle support.

Types of Performance Requirements

There are fourteen different performance requirements for structural fire fighting footwear. Table 9 provides a general description of how each test is conducted as well as

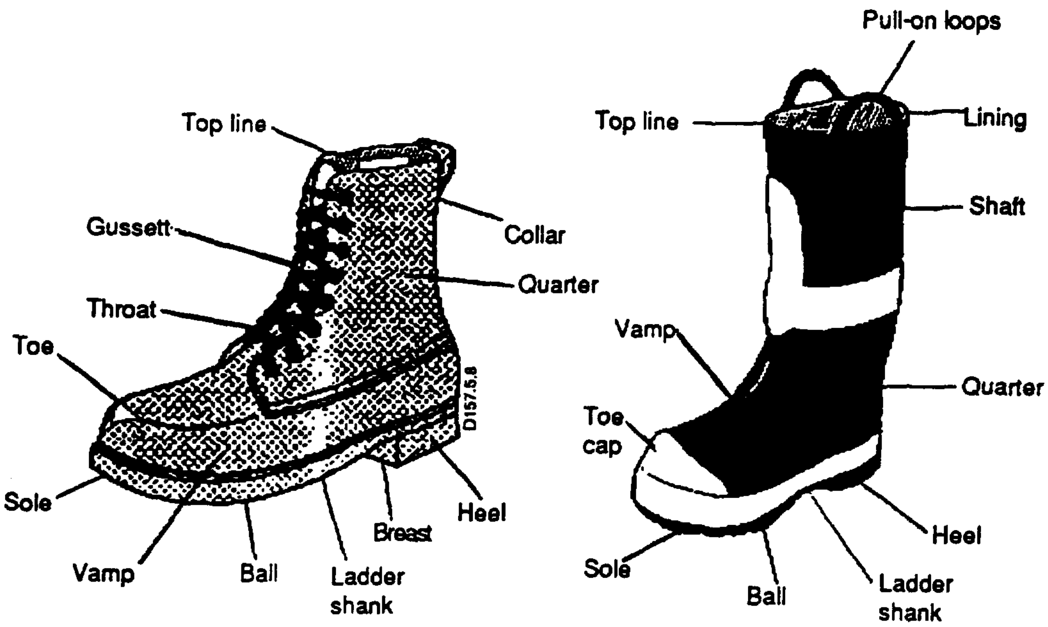

Figure 8. Typical Construction of Protective Footwear for Structural Fire Fighting

Table 9. NFPA 1974 Test Methods and Applications for Protective Footwear

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Conditioning Practices			
Preconditioning (5-l.1)	FTMS 191A, Section 4	A sample footwear material specimen is exposed to a temperature of 77°F and a relative humidity of 65% for 24 hours.	This practice is used to provide a controlled test environment. Test results could be biased if performed at different temperatures.
Wet conditioning (5-1.2)	Section 5-l.2	A sample material specimen (i.e., glove or footwear) is immersed in 70°F water for 1 hour. It is then permitted, to drain for 5 minutes.	This practice is used to provide a controlled test environment. Samples must be subjected to uniform conditioning practices in order to yield consistent results when simulating activity expected on the fire ground.
Mandatory Requirements			
Heat resistance (4-1.1)	Method appears in Section 5-2	After preconditioning, a sample boot is filled with vermiculite and placed in a forced air circulation oven at 500°F for 5 minutes. After exposure, the sample is examined for evidence of melting, dripping, separation, or ignition. Samples which exhibit this behavior fail the test.	This test measures how well footwear will withstand exposure to high heat as expected in fire ground activity. This test is intended to prevent materials or components which easily ignite from being used in the manufacturing of protective footwear. The 5 minute exposure at 500°F is representative of conditions expected during a flashover.
Metal part corrosion resistance (4-1.2)	ASTM B 117 (1985) (Section 5-8)	A sample of the metal components used in protective footwear is placed in a special chamber and sprayed with a 5 percent saline solution for 20 hours. Following exposure, the sample is examined for evidence of rust. If any signs of rust or corrosion are observed, the footwear fails the test.	This test provides a measure of the ease in which metal parts used in protective footwear will rust or corrode. Metal parts which exhibit this behavior will result in eventual footwear failure.

Table 9. NFPA 1974 Test Methods and Applications for Protective Footwear (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Sole/heel puncture resistance (4-1.3)	CSA Z195-M (Canadian Standards Association) (Section 5-9)	A samples of footwear sole/heel material is placed in a holder. The holder is attached to a tensile testing machine which has been outfitted with a compression cell. A probe, with dimensions similar to a 6 penny nail, is attached to the other end of the tensile testing machine. The probe is pushed into the material sample at a fixed rate of speed, and the force required to puncture the material is measured.	This test is designed to measure the resistance of the sole/heel material to sharp objects. Footwear must protect the tire fighter form sharp objects which may puncture the sole/heel material during fire ground activity. NFPA 1974 compliant footwear must not exhibit signs of puncture during this test.
Electrical resistance (4- 1.4)	ASTM F 1116 (1988) (Section 5-10)	A sample boot is filled with steel shot until the insole is completely covered. The boot is then placed in water so that the sole is completely immersed. Electrodes are placed in the shot inside the boot and in the outside water bath. A current of 14,000 volts is applied to sample and the current is measured through the circuit between the electrodes.	This test is a measure of how well protective footwear will provide electrical insulation. Since fire fighters may accidently step on a live electrical wire during fire ground activity, the footwear must insulate against electrical current. Footwear which exhibits signs of electrical current leakage in excess of 5 milliamperes fails the test.
Toe impact/ compression resistance (4-1.5)	ANSI Z41, Section 1.4	A footwear toe specimen is placed in a tensile test machine outfitted with a special device. An impact assembly is then dropped on the toe specimen. Following impact, the toe specimen is observed for signs of compression by measuring the clearance inside the specimen.	This test is used to measure how well the footwear will protect the wearer's toes from impact. Requirements for impact and compression resistance prevent injury to the toe when heavy objects ate dropped on the fire fighter's foot. Protective footwear must resist compression forces of 2500 pounds and impact forces of 75 foot-pounds or it fails the test.

Table 9. NFPA 1974 Test Methods and Applications for Protective Footwear (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Upper cut resistance (4-1.6)	Method appears in Section 5-3	Sample upper material specimens are preconditioned, A 2 x 4.5 inch test specimen is cut from the sample footwear and placed on a specimen support holder. The specimen and holder are then drawn under a weighted blade test fixture which uses a standard razor blade. Following this process, the material specimen is examined for evidence of cut through. If there is no cut through, the weight is increased on the fixture pivot arm which hold the razor blade until cut through occurs.	Sample materials must not permit cut through under a force of 16 pounds. This force has been judged as adequate to prevent different types of injuries which resulting from sharp-edged blades.
Upper puncture resistance (4-1.7)	ASTM F 1342 (1991)	A sample footwear upper material specimen is preconditioned and placed in a sample holder. The holder is attached to a tensile testing machine outfitted with a compression cell. A probe, with dimensions similar to a 6 penny nail, is attached to the other end of the testing machine. The probe is then pushed into the material sample at a fixed rate of speed, and the force required to puncture the material is measured.	Sample materials must withstand a puncture force of 13.2 pounds. This force has been judged as adequate to prevent different types of injuries which may occur due to footwear punctures.

Table 9. NFPA 1974 Test Methods and Applications for Protective Footwear (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Flame resistance (4-1.8)	FTMS 191A, 5903	A selected sample of footwear is suspended vertically over a 1 1/2 inch high flame produced by a methane gas source. The footwear material is placed in contact with the flame at the flames midpoint for 12 seconds. Following exposure, the time for which the sample continues to bum (afterflame) is recorded. The char length is then measured by attaching a weight to the specimen and measuring the length of the tear along the burn line. Notations are made if any evidence of melting or dripping is observed.	This test is a measure of how easily materials ignite and continue to bum once ignited. NFPA 1974 footwear samples cannot exhibit an average afterflame time greater than 2 seconds or a char length greater than 4 inches. In addition, no melting or dripping may be observed. This test does not represent all types of flame contact to which fire fighters may be exposed.
Sole/heel abrasion resistance (4-1.9)	ASTM D 1630 (1987)	A sample footwear sole/heel specimen is subjected to a NBS abrader. A special abradant wheel is used to abrade the specimen until 0.1 inch of material is removed. The number of revolutions required to perform the specified 0.1 inch abrasion is determined and compared to a standard reference sample. The number of revolutions required in the test sample is compared to the number of required in the control sample. This ratio yields a sole/heel abrasion resistance rating.	This test is a measure of the durability of the sole/heel material in protective footwear. A resistance rating of 65 is required for compliant fire tighter footwear.
Conductive heat resistance (4-l.10)	Method appears in Section 5-5	A sample boot is placed upright on a hot plate which is heated to a temperature of 932°F for 30 seconds so that the heel receives the heat exposure. A thermocouple is placed on the interior of the boot at the ball of the foot on the inside. The maximum temperature measured in recorded.	This test is a measure of the rate of heat transfer through the footwear sole and insole. NFPA 1974 requires the maximum measured amount of heat transfer to be less than 111°F.

Table 9. NFPA 1974 Test Methods and Applications for Protective Footwear (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Radiant heat resistance (4-1.11)	Method appears in Section 5-6	A sample boot is exposed to a radiant heat source so that a heat flux of 1 watt/cm^2 is achieved for one minute. A thermocouple is placed inside the sample boot on the side opposite to the heat exposure side to record the maximum temperature.	This test simulates the exposure of footwear to radiant heat. The temperature within the boot cannot exceed 111°F or the footwear fails the test.
Flex fatigue resistance (4-1.12)	FIA Standard 1209, Whole Shoe Flex as modified in Section 5-12	A sample boot is placed on a device which simulates walking 100,000 steps through repeated flexing. The boot is then tilled with water and examined for evidence of leakage.	Footwear must water-tight after simulated wearing.
Ladder shank bend resistance (4-l.13)	Method appears in Section 5-7	The rigid portion of the footwear insole is tested for deflection by placing a sample between two blocks and pushing down on its center. The amount of deflection is measured on both ends.	Ladder shanks are included in footwear to prevent insoles from bending while climbing ladders or stepping on narrow objects. This requirement ensures that protective footwear will have an acceptable amount of rigidity in the ladder shank insole.
Label permanency (4-1.14)	ASTM D 4966 (1989) (Section 5-4)	Two sample labels are subjected to 160 dry abrasion revolutions for 10 cycles. Two other sample labels are subjected to 80 abrasion revolutions for 5 cycles. Following the abrasion cycles, the sample labels are examined for legibility.	This procedure is a measure of label durability. Labels must remain intact and legible following all conditioning.

Table 9. NFPA 1974 Test Methods and Applications for Protective Footwear (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Optional Test			
Chemical penetration resistance (A-2-6.2)	ASTM F 903 (1990)	A 2.4 inch square material specimen is taken from a portion of the footwear and placed in a test cell. One side of the test cell is filled with a test chemical. The material specimen remains in the test chemical for one hour, of which one minute is at a pressure of 2 psi. Following exposure, the opposite side of the specimen is visually examined to determine if the liquid chemical has penetrated the samples. Samples exhibiting visual signs of penetration fail the test.	Footwear materials should resist penetration of selected chemicals for at least one hour. (A one hour exposure is considered a worse case scenario). This test evaluates the ability of the specimen sample to serve as a barrier to selected liquid chemicals. Other chemicals may permeate the material, and the material would still pass this test.

its application in providing fire fighter protection. The performance requirements address:

- *heat resistance,*
- *metal part corrosion resistance,*
- *sole/heel puncture resistance,*
- *electrical resistance,*
- *toe impact/compression resistance,*
- *upper cut resistance,*
- *upper puncture resistance,*
- *flame resistance,*
- *sole/heel abrasion resistance,*
- *conductive heat resistance,*
- *radiant heat resistance,*
- *whole boot water penetration resistance after flexing,*
- *ladder shank bend resistance, and*
- *label permanency.*

Some tests are conducted following conditioning practices intended to simulate specific environmental exposures. In addition to the fourteen requirements, there is one optional test for measuring the chemical penetration resistance of footwear. This test provides results indicating the effectiveness of footwear materials as a barrier to chemicals. The standard lacks criteria for thermal protective performance, ankle support and sole/heel slip resistance.

User Information Required or Supplied

Protective footwear manufacturers are required to provide instructions and information with each pair of footwear which cover:

- storage,
- marking,
- inspection,
- maintenance,
- retirement criteria,
- other information related to glove serviceability,
- cleaning and drying, including applicable warnings regarding detergents, soaps, cleaning additives, and bleaches, and
- a statement regarding footwear deterioration by chemicals.

In addition, other pertinent information and requirements are specified in NFPA 1500, *Standard on Fire Department Occupational Sqfety and Health Program.*

STATION/WORK UNIFORMS (NFPA 1975, 1990 Edition)

Scope and Limitation,

NFPA 1975, ***Standard on Station/Work Uniforms for Fire Fighters*** covers minimum general and performance requirements for test methods of textiles and other materials used in the construction of station or work uniforms worn by fire fighters. The standard is intended to specify station/work uniforms that will not contribute to fire fighter bums. In other words, the materials of construction should not be flammable or degrade in heat when worn with other protective clothing. NFPA 1975 is not a garment standard. All requirements apply strictly to the materials used in construction. Supplemental information is provided in the appendix which addresses additional material requirements, sizing, and seam strength. However, these requirements are not mandatory.

Basic Construction and Design Requirements

Station/work uniforms may include trousers, shirts, jackets, coveralls, t-shirts, or sweat shirts worn by fire fighters while on duty (underwear and socks are not included). These clothing items are typically made from one or more fabrics and thread for seams.

There are various components of station/work uniforms. Interlinings are fabrics that are incorporated between a lining and the outer shell of a garment during construction. Some materials are woven into fabrics while others are knit into fabrics. A long sleeve dress shirt is a woven product, whereas a standard t-shirt is a knit product. Knit products typically have much greater "stretch" than woven products. Station/work uniforms may also include various components such as buttons, zippers, snaps, or hook and loop fasteners. However, these have no specific design requirements in NFPA 1975 standards.

Types of Performance Requirements

There are four general test requirements in NFPA 1975.

- ***Flame Resistance.*** Textile fabrics and interlinings used in the construction of station/work uniforms are tested for vertical flame resistance.

- ***Heat Resistance.*** Heat or oven resistance is measured for all textile fabrics, interlinings, components, and other materials. Elastic and hook and pile fasteners which are not placed in direct contact with the body, are excluded. The maximum exposure temperature is 500°F.

- ***Melting Resistance.*** Thread used in the construction of the garment is subjected to a melting resistance test.

- ***Labelling.*** Station/work uniforms must have a label which includes specific language from NFPA 1975 regarding the use of the garment, and information which identifies the manufacturer and materials of construction. In addition, the label must be readable from a distance of 12 inches.

Additional optional requirements are included in the standard's appendix which address:

- fabric weight,
- material strength,
- material tearing resistance,
- material bursting strength,
- laundering shrinkage,
- laundering colorfastness,
- crocking colorfastness,
- light colorfastness, and
- seam strength/efficiency.

NFPA 1975 provides recommendations for minimum and/or maximum requirements in each of these performance areas. A description of the test methods and their application in purchase specifications is presented in Table 10.

NOTE: At the time of publication, several changes were proposed to provide additional performance requirements for station/work uniform materials including thermal shrinkage resistance, tearing resistance, and seam strength.

Table 10. NFPA 1975 Test Methods and Applications for Station/Work Uniforms

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Mandatory Tests			
Flame resistance (3-l.1)	FTMS 191A, 5903.1 Laundering per AATCC 135 (1987): Machine Cycle 3; Wash Temp. IV; and Drying Proc. Aiii Drycleaning per commercial process (Section 4-2)	A 2 x 8 inch material specimen is placed in a holder that is suspended vertically over a 1 112 inch high flame. The flame is produced by a methane gas source. The material is placed in contact with the flame at the flame's mid point for a period of 12 seconds. After exposure to the flame, the amount of time during which the specimen continues to bum (afterflame) is recorded. The length of the bum or char length is then measured by attaching a weight to the specimen and measuring the length of the tear along the bum line. Notations are recorded if any melting or dripping is observed. Samples are tested in this manner both before and after 50 wash/dry cycles, or 25 drycleaning cycles.	This test is used to determine how easily materials ignite, and how easily they continue to burn once ignited. In order to pass NFPA 1975, materials cannot have an average afterflame time greater than 2 seconds, a char length greater than 6 inches, or any melting or dripping. This requirement is less stringent for other products governed by NFPA standards such as protective clothing, gloves, and boots. In addition, this test is not representative of all types of flame contact to which fire fighters may be exposed.
Heat resistance (3-1.2)	Method appears as Section 4-3	A material sample, 6 inch square, is suspended in a forced air-circulating oven at 500°F. Following a 5 minute exposure, the sample is examined for evidence of melting, dripping, separation, or ignition. Samples which demonstrate such behavior fail the test.	This test measures the components of station/work uniforms following an exposure to the high heat expected in fire ground activity. The purpose of the test is to prevent materials or components which easily ignite, melt, drip, or separate during exposure to high heat from being used in station/work uniforms.

Table 10. NFPA 1975 Test Methods and Applications for Station/Work Uniforms (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Thread melting resistance (3-1.3)	FTMS 191A, 1534 (Section 4-4)	A small segment of thread used in the stitching of station/work uniforms is placed in a flask containing an organic solvent and heated. (The solvent extracts substances which would interfere with the test.) Next, the extracted thread segment is put in a device which slowly heats the thread. The temperature at which the thread begins to melt is the melting temperature.	Thread used in station/work uniforms must withstand temperatures of up to 500°F. If the melting temperature is less than 500°F the thread fails the test. The temperature, 500°F, is consistent with the heat resistance test.
Label legibility (3-1.4)	AATCC 135 (1987): Machine Cycle 3; Wash Temperature IV; and Drying Procedure Aiii (Section 4-5)	Sample labels must contain the required language as stated in NFPA 1975. They are subjected to 100 wash/dry cycles, and then examined for legibility.	This requirement checks for label durability. Following this test, the labels must remain legible from a distance of at least 12 inches.
Optional Tests			
Fabric Weight (A-l-l.1)	ASTM D 3776 (1979)	A 6 inch square of fabric is weighed using a laboratory balance. The measured weight is divided by the area of the fabric. This yields a fabric weight in ounces per square yard.	Recommended minimum weights are specified for woven materials: ● jackets 5.5 on/yd ● trousers 5.5 on/yd ● woven shirts 4.0 on/yd ● knit t-shuts 3.0 on/yd ● knit sweat shirts 7.0 on/yd Fabric weights may be heavier than the specified requirements, but the clothing may be less comfortable during warmer weather.

Table 10. NFPA 1975 Test Methods and Applications for Station/Work Uniforms (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Material tensile strength (A-1-1.1)	ASTM D 1682 (1975)	In this test, a 4 x 8 inch material specimen is placed between the two grips of a tensile testing machine and pulled until it breaks. The force measured at the site of the break is the material strength.	Tensile strength is a measurement which describes the ease with which a woven material can be pulled apart. NFPA 1975 recommends that woven trousers and jackets have a minimum material strength of 50 pounds. Shirts should have a minimum material strength of 20 pounds.
Material tear resistance (A-1-1.1)	ASTM D 1424 (1981)	In this test, a notched 4 x 6 inch material specimen is placed into a test device. The test device uses a pendulum which is allowed to fall. The force of the falling, pendulum tears the material beyond the notch. This test measures the force in pounds which is required to continue a tear in the notched test specimen.	Tear resistance is a measurement of the ease with which a woven fabric can be tom apart. NFPA 1975 recommends that woven trousers and jackets have a minimum tear resistance of 5 pounds. Woven shirts should resist up to 2 pounds of tearing force.
Material burst strength (A-1-1.1)	ASTM D 3787 (1980)	This test measures the force required to burst a knit or stretch woven fabric. A material specimen is clamped over a diaphragm which is inflated until the specimen bursts. The pressure at which the material bursts is the bursting strength.	Burst strength is a measure of how easily a knit fabric can be penetrated by a hard round object. NFPA 1975 recommends burst strengths of 35 and 50 pounds respectively for knit t-shirts and sweat shirts.
Laundering shrinkage (A-1-1.1)	AATCC 135 (1987): Machine Cycle 3; Wash Temp. IV; and Drying Proc. Aiii (5 washes)	A material sample is subjected to five separate wash/dry cycles under controlled conditions. Following the washing and drying, the dimensions of the material sample are compared to its original dimensions.	Laundering shrinkage is a measure of the Percentage a fabric shrinks after laundering. NFPA 1975 recommends that woven fabrics shrink no more than 3%. Knit fabrics should not shrink more than 12%.

Table 10. NFPA 1975 Test Methods and Applications for Station/Work Uniforms (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Laundering colorfastness (A-1-1.1)	AATCC 61 (1980), Procedure 11, A	A material sample is subjected to controlled washing and drying conditions. Following exposure, the color of the material sample is compared to a color scale chart which indicates the degree of a color change.	Laundering colorfastness assesses the amount of color change, or fading, which occurs in the fabric following exposure to water or drycleaning solvents. NFPA 1975 recommends a rating of at least "3" for all station/work uniform materials.
Crocking colorfastness (A-1-1.1)	AATCC 8 (1981)	In this test method, a material sample is placed in a device against a white transfer cloth. The device rubs the material together. The amount of color which is transferred to the white transfer cloth is assessed by a rating scale of 1 to 5 (1 being worst).	Crocking colorfastness is a measure of the amount of color or dye that is transferred from the fabric by rubbing or abrasion. NFPA 1975 recommends that all station/work uniform materials have a rating of "3".
Light colorfastness (A-1-1.1)	AATCC 16E (1982)	A material specimen is placed in a weatherometer which simulates intense exposure to sunlight and humidity. The exposure test is conducted for a total of 2 weeks. Following the exposure, the material is compared to a colorfastness rating scale.	Light colorfastness is a measure of the amount of color loss in a fabric due to extended exposure to light. NFPA 1975 recommends that all station/work uniform materials have a colorfastness rating of "3".
Seam efficiency (A-3-1.3)	ASTM D 1683 (1981)	The strength of a seam is measured in the same way as material tensile strength. In this test, a material seam specimen is placed between two grips in a tensile testing machine and pulled until it breaks. The force to break the seam is compared to the force to break the material by itself.	Seam efficiency compares the strength of a seam to the fabric which it joins. NFPA 1975 recommends that critical seams of inherently flame-resistant fabrics have a seam efficiency of 65% Critical seams of flame retardant-treated fabrics are required to have a seam efficiency of 75%.

SELF-CONTAINED BREATHING APPARATUS, (NFPA 1981, 1992 Edition)

Scope and Limitations

NFPA 1981, ***Standard on Open-Circuit Self-Contained Breathing Apparatus for Fire Fighters,*** sets performance criteria which extend beyond requirements set in the NIOSH certification of positive pressure open circuit self-contained breathing apparatus. The additional requirements of NFPA 1981 address flame/thermal and physical hazards specific to the fire ground.

A ***self contained breathing apparatus (SCBA)*** is a respirator which supplies a respirable atmosphere to the user, carried in or generated by the apparatus independent of the outside environment. ***Open-circuit*** SCBA are those in which exhalation is vented to the atmosphere and not re-inhaled. This type of SCBA may be either negative pressure (demand type) or positive pressure (pressure demand type), **NFPA 1981 requires positive pressure SCBA only.** ***Positive pressure*** SCBA are those SCBA in which the pressure inside the face piece, in relation to the pressure surrounding the outside of the face piece, is positive during both inhalation and exhalation when tested to NIOSH requirements (30 CFR 11, Subpart H). NFPA 1981 applies to SCBA used in fire fighting, rescue, and other hazardous duties. It does not apply to closed-circuit SCBA or rebreathers.

Basic Construction and Design Requirements

The primary design requirements for SCBA are specified by NIOSH in the Code of Federal Regulations (30 CFR 11, Subpart H). The layout of a typical SCBA is shown in Figure 9. NFPA 1981 requires NIOSH/MSHA (Mine Safety and Health Administration) certification of SCBA prior to NFPA 1981 certification testing. In addition, NFPA 1981 requires that SCBA weigh no more than 35 pounds and be rated to at least 30 minutes, as certified by NIOSH/MSHA.

Types of Performance Requirements

In response to specific fire service needs, NFPA 1981 provides performance requirements that are not part of NIOSH/MSHA certification. NFPA 1981 requires that 4 separate SCBA be submitted for testing. Each SCBA is submitted to a series of tests. In addition, specific SCBA components are submitted for different tests. Performance tests include:

- *air flow peformance,*
- *environmental temperature performance,*
- *vibration resistance performance,*
- *fabric flame resistance,*
- *fabric heat resistance,*
- *thread heat resistance,*

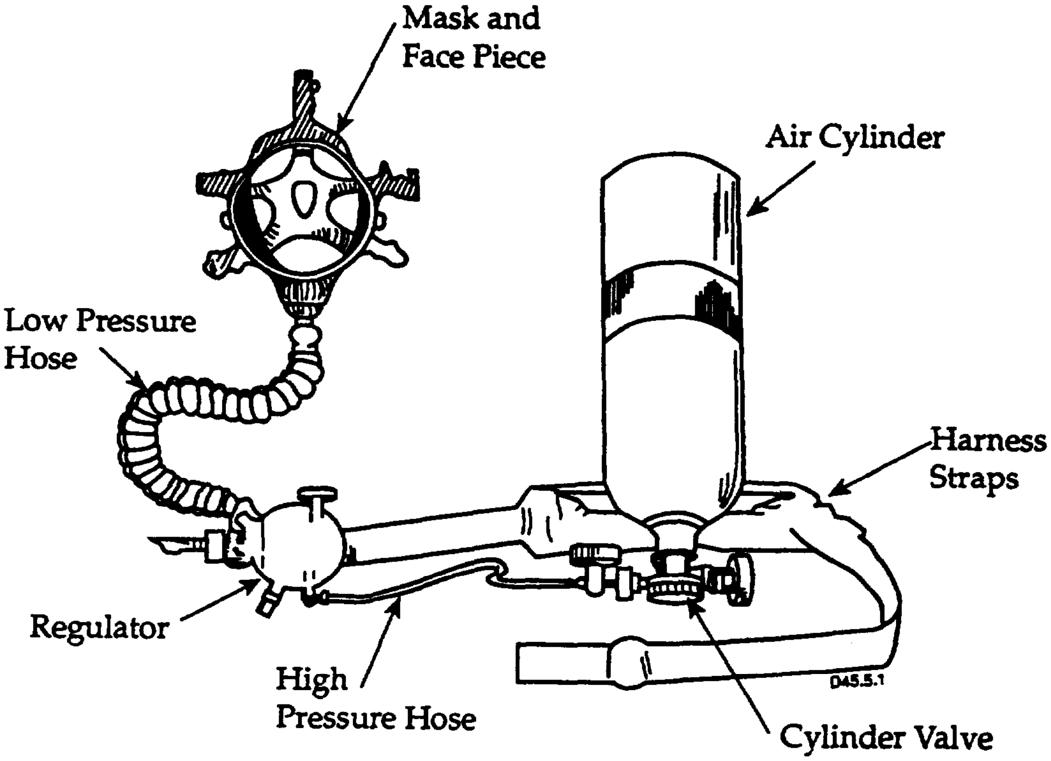

Figure 9. Sample Self-Contained Breathing Apparatus

- *accelerated corrosion resistance peformance,*
- *particulate resistance performance,*
- *facepiece lens abrasion resistance,*
- *communications performance, and*
- *overall SCBA heat/flame resistance performance.*

Each of these tests and their application within the standard are further described in Table 11.

User Information Required or Supplied

SCBA manufacturers are required to provide instructions and information with each breathing apparatus that cover:

- maintenance,
- cleaning,
- disinfecting,
- storage, and
- inspection.

Manufacturers must also provide specific instructions and training materials regarding:

- the user,
- operation,
- safety considerations, and
- SCBA limitations.

A discussion is provided in the appendix of the standard, Section A-2-1.3 about factors limiting the service life of SCBAs. In addition, other pertinent information and requirements are specified in NFPA 1500, ***Standard on Fire Department Occupational Safety and Health Program.*** NFPA 1500 includes a number of provisions which address use of SCBA including:

- situations requiring SCBA use,
- type and frequency for testing the quality of breathing air,
- respirator fit testing, and
- beards and the wearing of glasses or contact lens with SCBA.

NOTE: A separate standard is being developed for closed-circuit, self-contained breathing apparatus.

Table 11. NFPA 1981 Test Methods and Applications for SCBA

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Air flow performance (3-1)	Method appears in Section 4-1	A sample self-contained breathing apparatus (SCBA) is placed onto a breathing machine and the facemask is attached to a headform. The breathing machine simulates breathing at a ventilation rate of 100 liters/minute and a respiratory frequency of 30 breaths/minute. A pressure transducer within the headform measures the pressure inside the mask at the breathing zone.	This test simulates the high breathing rates which are not covered in NIOSH certification. Mask pressure is monitored for negative pressure. Negative pressures within the mask can potentially pull in contaminated outside air. NFPA 1981 compliant SCBAs do not exhibit negative pressures under these test breathing conditions.
Environmental temperature performance (3-2)	Method appears in Section 4-2	The air flow performance described in the previous teat method for section 4-1 is measured using a SCBA under four separate environmental conditions: 1) SCBA exposure to -25°F for 12 hour, 2) SCBA exposure to 160°F for 12 hours, 3) SCBA exposure to condition 2 followed by condition 1, and 4) SCBA exposure to condition 1 followed by condition 2.	These tests are designed to determine SCBA performance under temperature extremes, and changes represented by hot and cold environmental conditions. The SCBA must not exhibit negative pressures during the air flow test.
Vibration resistance (3-3)	MIL-STD-810E, Method 514.4; Method appears in Section 4-3	In vibration testing, Sample SCBA are restrained in a wooden box that vibrates in two different orientations for 90 minutes each. The air flow performance described in the test method cited in Section 4-1 is then measured for sample SCBA.	This test simulates vibration which started the SCBA may experience in transmit aboard a fire apparatus. Its subsequent performance in providing fire fighter respiratory protection is then measured. The SCBA must not exhibit negative pressures during the air flow test.

Table 11. NFPA 1981 Test Methods and Applications for SCBA (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Fabric flame resistance (34)	FTMS 191A, 5903.1 AATCC 135 (1987), Machine Cycle 1; Wash Temperature V; and Drying Procedure Ai (Section 4-4)	A material specimen is placed in a holder and suspended vertically over a 1 1/2 inch high flame, produced by a methane gas source. The material is placed in contact with the flame at the flame is midpoint for 12 seconds. After exposure, the time the sample continues to bum (afterflame) is recorded. The char length is measured by attaching a weight to the specimen and measuring the length of the tear along the bum line. Notations are made if any melting or dripping is observed.	This test measures how easily SCBA fabric materials ignite and continue to bum once ignited. In order to pass NFPA 1981, compliant fabric materials used in the construction of the SCBA cannot show an average afterflame time of greater than 2 seconds or a char length greater than 4 inches. In addition, no melting or dripping may be observed.
Fabric heat resistance (3-5)	Method appears in Section 4-5; AATCC 135 (1987). Machine Cycle 1; Wash Temperature V; and Drying Procedure Ai	A fabric specimen is suspended in a forced air circulation oven at 500°F for 5 minutes. Following exposure, the specimen is examined for evidence of melting, separation, or ignition. Samples which exhibit this behavior fail the test.	This test measures how well SCBA fabrics resist exposure to the high heat expected during fire ground activity. It is intended to prevent fabrics which easily ignite, melt, or separate from being Used in the manufacture of protective clothing items.
Thread heat resistance (3-6)	FTMS 191A, 5134 (Section 4-6)	A small segment of sample thread used in SCBA construction is placed in a flask containing an organic solvent and heated. (The heat extracts substances which would interfere with the test.) Next, the extracted thread segments are put into a device which slowly heats the thread. The temperature at which the thread begins to melt is recorded.	Thread used in SCBAs cannot melt at temperatures less than 500°F. This temperature has been selected in order to be consistent with the heat resistance test.

Table 11. NFPA 1981 Test Methods and Applications for SCBA (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Accelerated corrosion resistance (3-7)	MIL-STD-810E, Method 509.3; Method appears in Section 4-7	A sample SCBA is placed on a mannequin. The mannequin is then placed in a closed chamber and exposed to a 5% salt fog for 48 hours. Next, it is removed and exposed to an environment with a temperature of 72°F and 50% relative humidity. The sample SCBA is then tested for air flow performance as described in the test method cited for Section 4-1.	This test simulates the impact of corrosive environments on SCBA performance. The SCBA must not exhibit negative pressures during the air flow test.
Particulate resistance (3-8)	MIL-STD-810E, Method 510.3; Method appears in Section 4-8	A sample SCBA is placed on a mannequin. The mannequin is then placed in a closed chamber. The SCBA is connected to a breathing machine which produces a ventilation rate of 40 liters/minute at a respiration frequency of 10 breaths/minute. The SCBA on the mannequin is then exposed to a dust atmosphere for one hour. The sample SCBA is then tested for air flow performance as described above the test method cited in Section 4-1.	This test simulates the impact of particulate laden environments on SCBA performance. The SCBA must not exhibit negative pressures during the air flow test.
Facepiece lens abrasion resistance (3-9)	Method appears in Section 4-9	A SCBA facepiece lens specimen is placed in an abrader. The outside surface of the lens is abraded with a wood finishing pad using a 2.2 pound weight for 200 cycles. The haze is measured for both abraded and unabraded samples.	This test simulates the exposure of the facepiece lens to abrasion as would be expected during routine use. The abraded samples may not produce greater than 14% more haze compared to the non-abraded samples.

Table 11. NFPA 1981 Test Methods and Applications for SCBA (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Communication Performance (3-10)	ANSI S3.2; Method appears in Section 4-10	Five pairs of talkers and listeners are selected. (A talker reads selected material, and a listener writes the words he or she hears. The talkers and listeners are 5 feet apart. The test is scored on the number of words correctly understood by the listener while wearing a SCBA. The test is repeated without SCBA, and the scores are compared.	This test is a measure of the ability of a fire fighter to be correctly understood while speaking and wearing SCBA. Manufacturers may use a variety of methods to accomplish this task, including speaking diaphragms or other devices. NFPA 1981 requires the average listener score to be at least 72% correct.
Overall Heat and Flame Resistance (3-11)	Method appears in Section 4-11	An SCBA is placed on an upper torso mannequin which is wearing a tire tighter protective coat. The headform of the mannequin is attached to a breathing machine. The breathing machine is set at 40 liters/minute and 12 breaths per minute. The mannequin assembly is then placed in a forced air circulating oven at 203°F for 15 minutes. Following this exposure, the ventilation rate is increased to 100 liters/minute. The mannequin assembly is then removed from the oven and exposed to direct flame from four burners (two directed at the mannequin's back and two at the front) for 10 seconds. The entire assembly is then raised 6 inches and dropped.	This test simulates a number of events expected during fire fighting activity. The initial heat exposure is representative of the tire fighter in tire ground activity, the direct flame contact represents the fire fighter engulfed in flames, and the drop simulates a shock to the SCBA that may occur when the wearer jumps or bumps the SCBA against an object. Requirements specify that SCBA cannot exhibit negative pressures during the test. In addition, no components may exhibit flame for longer than 2.2 seconds, and no components may become loose or separated. (A human subject must also able to read an eye chart using the SCBA test mask without distortion at the 20/100 activity level).

PERSONAL ALERT SAFETY SYSTEM (NFPA 1982, 1993 Edition)

Scope and Limitations

NFPA 1982, ***Standard on Personnel Alert Safety Systems (PASS) for Fire Fighters,*** specifies minimum design and performance criteria for PASS units to be used by fire fighters engaged in fire fighting, rescue, and other hazardous duties. The PASS unit is intended to provide a loud audible warning signal in the event that the fire fighter remains motionless for more than 30 seconds or is self activated if the fire tighter becomes in trouble. It is a means for identifying the location of fire fighters who have been injured or cannot move. Under NFPA 1982, PASS units are tested for conditions or performance related to approach, proximity, entry fire fighting, or hazardous chemical operations.

Basic Construction and Design Requirements

NFPA 1982 does not include any specific requirements for the PASS size, weight, or the methods of attachment to the fire tighter. Design requirements address:

- ***Mode selection.*** PASS units must incorporate a mode selection device that allows for operation in three modes: off, manual, and automatic.

- ***The motion detector.*** The PASS unit alarm signal must activate after 30 seconds if movement is sensed. The alarm signal must be preceded by a pre-alarm signal for 10 seconds. The motion detector must operate independent of its orientation.

- ***Signals.*** PASS units must have operational, pre-alert, alarm, and low battery warning signals. NFPA 1982 specifies the frequency and length for each signal.

- ***General configuration.*** The PASS unit requires a retention system, and that the battery compartment be isolated from operating components to prevent damage due to battery leakage.

There are no requirements which address the type of battery or how long it lasts.

Types of Performance Requirements

NFPA 1982 requires that 12 separate PASS units be submitted for testing. Each SCBA is submitted to a series of tests, which include:

- *sound pressure level,*
- *electronic temperature stress,*
- *corrosion resistance,*
- *immersion/leakage resistance,*

- *case integrity,*
- *shock sensitivity,*
- *impact resistance,*
- *retention system strength,*
- *water drainage,*
- *heat resistance, and*
- *overall heat/fame resistance.*

A complete description of each test and its application is shown in Table 12.

User Information Required or Supplied

PASS manufacturers are required to provide instructions and information with each PASS unit which cover:

- maintenance,
- decontamination,
- cleaning,
- painting,
- inspection frequency and details,
- use,
- operation,
- limitations of PASS,
- training materials, and
- warranty information.

In addition, other pertinent information and requirements are given in the NFPA 1500, ***Standard on Fire Department Occupational Safety and Health Program.*** This standard proscribes wearing the PASS unit on the fire fighter's body. If the PASS is attached to the SCBA, it may not be effective if the fire fighter removes the breathing apparatus during certain stages of work at the fire ground.

Table 12. NFPA 1982 Test Methods and Applications for PASS

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Sound pressure level (4-1)	Method appears in Section 5-1	The sound pressure or signal volume of a sample PASS unit is measured at specified distances. Three different signals are measured: pre-alert, alarm, and low battery warning.	This test measures how effective the PASS units are by determining their ability to be heard. NFPA 1982 requires that pre-alert and low battery warning signals have a sound pressure level between 70 and 85 decibels. Alarm signals must have a sound pressure of at least 95 decibels.
Electronic temperature stress (4-2)	Method appears in Section 5-2	A sample PASS unit is exposed to three different environmental conditions: cold, heat, and alternating cold and heat. The heat condition includes alternating temperature exposures of 120°F and 160°F for 30 hours. The cold condition involves temperature exposures of -70°F for 28 hours and then exposure to -40°F for 4 hours. The alternating cold and heat condition involves repeated alternating exposures to -40°F and 160°F. Following exposure to each of these conditions, the PASS unit is evaluated for proper functioning.	This test simulates environmental extremes to which PASS units may be subjected during routine use. The motion sensing capability and signal response must remain functional after these exposures.
Corrosion resistance (4-3)	ASTM B 117 (1985); Method appears in Section 5-3	A sample PASS unit is placed in a closed chamber and exposed to a 5% salt spray for 48 hours. Following exposure, it is evaluated for proper functioning.	This test simulates the harsh conditions of a corrosive environment. The motion sensing capability and signal response must remain functional after these exposures.
Immersion/leakage resistance (4-4)	Method appears in Section 5-4	A sample PASS unit is immersed in water for 2 hours, and then tested for proper functioning. The PASS unit is also opened and examined for signs of water penetration.	This test simulates dropping a PASS unit into water. The motion sensing capability and signal response must remain functional after this exposure.

Table 12. NFPA 1982 Test Methods and Applications for PASS (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Case integrity (4-5)	Method appears in Section 5-5	A 442 pound weight is placed on each surface of a sample PASS unit. The PASS unit is then tested for proper functioning. The integrity of the PASS unit case is also examined for evidence of damage.	This test simulates large weights being placed on a PASS unit or the unit being stepped on. The motion sensing capability and signal response must remain functional after removal of the weight.
Shock sensitivity (4-6)	Method appears in Section 5-6	A 5/16 inch diameter steel ball is dropped down a 6 inch tube onto a sample PASS unit. The PASS unit is operated in the automatic mode during the sounding of the pre-alert signal. The sounding of the pre-alert signal is monitored to determine pass/fail.	This test simulates the physical shocks and jolting to which the PASS unit may be subjected. The pre-alert signal must not cancel after the shock is delivered to the PASS unit.
Impact resistance (4-7)	Method appears in Section 5-7	A sample PASS unit is exposed to one of three conditions: 1) ambient temperature exposure, 2) 4 hours of temperature exposure at -40°F. or 3) 4 hours of temperature exposure at 160°F. It is then dropped 8 times from a distance of 9.9 feet. Following exposure to these environmental conditions, the PASS unit is evaluated for proper functioning.	This test simulates a more serious shock to the PASS unit such as a long drop or fall. The motion sensing capability and signal response must remain functional after being dropped following exposure to each environmental condition.
Retention system (4-8)	Method appears in Section 5-8	The retention apparatus used to attach a PASS unit is cycled 500 times. The retention system is then pulled from the sample PASS unit. The force at which the retention system separates is measured.	This test measures how well PASS units will remain in place. PASS units should always remain in place and should not be easily removable due to retention system failure. The retention system must be able to withstand a 100 pound force.

Table 12. NFPA 1982 Test Methods and Applications for PASS (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Water Drainage (4-9)	Method appears in Section 5-9	Water is directed into all openings and grilles of a sample PASS unit. The PASS unit is then evaluated for proper functioning.	Water which is retained in the PASS unit openings can potentially affect performance. The motion sensing capability and signal response must remain functional after the PASS is filled with water.
Heat resistance (4-10)	Method appears in Section 5-10	A sample PASS unit is placed in a force air circulating oven at a 500°F for 30 minutes. The sample PASS unit is then examined for evidence of heat damage and evaluated for proper functioning.	This test measures the ability of the PASS unit to withstand exposure to high heat as expected in fire ground activity. The PASS unit components cannot exhibit evidence of melting, dripping, or igniting.
Overall heat and flame resistance (4-11)	Method appears in Section 5-11	A sample PASS unit is placed on an upper torso mannequin which is wearing a tire tighter protective coat. The mannequin assembly is placed in a forced air circulating oven at 203°F for 15 minutes. Next, the mannequin assembly is exposed to direct flame from four burners, (two directed at the mannequins back and two at the front) for 10 seconds. The mannequin assembly is then raised 6 inches and dropped. Three separate tests are conducted. In the first, the PASS unit is set in the manual mode and the alarm sounding is tested. In the second and third tests, the PASS is set in automatic mode, and the operational signals are tested.	This test simulates a number of events common in fire fighting activity. The initial heat exposure is representative of the fire fighter in fire ground activity, the direct flame contact represents a fire tighter being is engulfed in flames, and the drop simulates a shock to the PASS that may occur when the wearer jumps or bumps the PASS against an object. Requirements specify that the PASS unit should function properly, that no components should show after flame for more than 2.2 seconds, and that no components should become loose or separated.
Product label durability (4-12)	Method appears in Section 5-12	A sample PASS unit is subjected to electronics temperature stress, corrosion, and immersion/leakage testing. It is then examined for durability.	This test ensures that PASS labels remain legible following exposure to various environmental conditions.

Table 12. NFPA 1982 Test Methods and Applications for PASS (Continued)

Requirement (Section No.)	Test Method Cited	Description of Test Method	Application of Test Method
Intrinsic safety (4-13)	ANSI/UL 913	A sample PASS unit is evaluated for safe performance in a hazardous environment.	PASS units must meet the requirements for Class 1, Division 1 hazardous locations. These criteria prevent PASS units from causing electricaI sparks which could potentially ignite flammable environments.

SELECTION AND PROCUREMENT GUIDELINES

Due to the variety of products available, selecting and procuring the most appropriate protective clothing or equipment can be a difficult process. It is important that protective clothing and equipment be acquired that meets all department criteria. The NFPA standards serve as a good starting point for specifying clothing or equipment requirements, but additional steps must be taken to ensure that departments get clothing that meets their needs. These step include:

1. **Identify the specific needs of your department.** Each department has its own unique equipment and operating procedures.

   - Examine current problems or injuries in using protective clothing and equipment. Determine what performance is needed to overcome these limitations.

   - Consider current protective clothing and equipment and its compatibility with the items to be purchased.

   - Determine if there are specific areas of protection that are required but are not covered in available specifications.

   - Decide on clothing sizing and design issues. For example, your department may have a preference for clothing color and trim style. Also, special pockets may be required to hold radios or other equipment.

2. **Write specifications that will meet these needs.** The specifications serve as a way to translate department needs into a set of requirements that can be met by manufacturers of protective products.

   - Solicit help from other organizations (such as NAFER or SAFER) or departments who may have already developed specifications that you can use or modify.

   - Use NFPA standards as the basis for purchase specifications. If deviations from a NFPA standard are made, thoroughly document the reasons for the deviation. This limits department liability.

   - If trying to purchase specific manufacturer products, determine those product characteristics that are unique which can be specified.

   - Establish rating criteria ahead of time that will allow you to evaluate products to your specification.

- Include provisions for returning unsatisfactory products and assessing penalties if bid specifications are not met.

3. **Solicit bids for the clothing or equipment needed.** There are many ways to improve the quantity and quality of information received from prospective offerers.

    - Increase purchasing power by forming collective buys with other departments to obtain larger quantities at volume discounts.

    - Require manufacturers to provide one or more samples that can be evaluated. Develop a test plan to evaluate the sample and compare its performance to competing products.

    - Specify that manufacturers show evidence of compliance with the appropriate NFPA standard. Have manufacturers supply all data showing compliance of their product in a format that will allow your department to compare all competing products easily.

    - Require manufacturers provide complete user instructions and copies of warranties and technical data for examination.

4. **Thoroughly evaluate bids.**

    - Carefully check sample clothing against the developed specification.

    - Examine information supplied with the products such as instructions, warranties, and technical data. Look for completeness of the information and ease of its use.

    - Employ an evaluation system to rate products.

    - Physically wear or use equipment to ensure that it meets original specifications.

5. **Evaluate the performance of the clothing or equipment to determine if it does meet the original needs.**

    - Once clothing or equipment has been received, establish standard operating procedures (SOP's) for its use, care, and maintenance.

    - Periodically review how clothing or equipment meets fire department needs.

    - Revise specifications as needed for new or replacement clothing and equipment. Use the standard as the basis for your specifications.

PARTICIPATING IN THE NFPA

If you have concerns or needs about standards which you do not feel are being adequately met, the NFPA encourages outside input. This can be done in two ways through the NFPA process:

1. **First you can submit a public proposal.** In the back of each standard is a form that you can fill out and submit to the **NFPA.** Your proposal must provide a statement of the problem, a specific recommendation to the committee, and substantiation for your recommendations. Public Proposals should be send to:

   Secretary, Standards Council
   National Fire Protection Association
   1 Batterymarch Park
   Quincy, MA 02269

2. **Second, you can comment on a proposed changes on a new or existing standard.** After the subcommittee and Technical committees develop or revise a NFPA standard, the new proposed editions will appear in the Technical Committee reports. This publication is send out to the NFPA membership but is available to anyone free of charge.

   TO RECEIVE A COPY OF THE TECHNICAL COMMITTEE REPORTS, CALL NFPA AT l-617-770-3000

   After the Technical Committee Reports are out, you can make comments and recommendations to the proposed revised standards in the form of public comments. Like public proposals, NFPA provides a specific form to submit your comments and recommendations. This form appears in the front of the Technical Committee report and are prepared in a similar manner as the public proposal.

   PUBLIC COMMENTS MUST INCLUDE:
   - an identified section,
   - a recommended change, and
   - reasons for the change.

   It is particularly important that you make address individual sections of the standard, make a specific recommendation for changing the standard, and provide reasons for your recommended change.

Both of these comment periods allow you formally to make your recommendations. The subcommittee and Technical Committee are required to respond to each public proposal and comment submitted. They can either adopt it, reject it, or hold for further study. All comments and the committee’s responses are published by the NFPA for further review.

GLOSSARY

Abrasion. The wearing away of any part of a material by rubbing against another surface.

Afterflame Time. The length of time for which a material continues to flame after the ignition source has been removed.

Afterglow, Glow which persists in the material after the removal of an external ignition source or after the cessation (natural or induced) of flaming of the material.

Air Permeability. The rate of air flow through a material under a differential pressure between two fabric surfaces.

Alarm Signal. An identifiable audible warning which indicates that a fire fighter is in need of assistance.

Annunciator. The device on a PASS unit designed to emit the alarm signal.

Approach Clothing. Protective clothing designed to provide protection from radiant heat.

Automatic. A functional mode in which the PASS motion detector is activated and is sensing motion of the wearer.

Basic Plane. In describing the position of a helmet, the plane running through the centers of the external ear openings and the lower edges of the eye sockets.

Basic Weight. The weight of the helmet including all accessories.

Bitragion Coronal Are. In describing the position of a helmet, the arc between the right and left tragion as measured over the top of the head in a plane perpendicular to the mid-sagittal plane.

Bitragion Inion Are. In describing the position of a helmet, the arc between tragion as measured over inion.

Breaking Strength. The capacity of a specific material to withstand the ultimate tensile load or force required to pull the material apart.

Breathability. In testing protective clothing materials, the capacity of a material to allow air permeability and water vapor transmission.

Brim. A part of the shell of the helmet extending around the entire circumference of the helmet.

Brim Line. A horizontal plane intersecting the lowest point of the brim at the lateral midpoint of the helmet.

Bursting Strength. The force or pressure required to rupture a textile by expanding it with a force applied perpendicular to the fabric surface.

Cargo Pockets. Pockets located on the protective garment exterior.

Char Length. The distance a material bums after being exposed to a flame as measured using a weight to tear the material. Specifically, the distance the material teared along the burned area is the char length.

Charring. The formation of carbonaceous residue as the result of pyrolysis or imcomplete combustion of the material.

Chemical Penetration. The bulk flow of a liquid chemical through seams, closures, and opening or pores and imperfection in a clothing material.

Chin strap. An adjustable strap, fitting under the chin, to secure the helmet to the head.

Cleaning Shrinkage. The change in dimension of a fabric specimen after exposure to a specified cleaning process.

Clo. A unit of thermal resistance defined as the insulation required to keep a resting man comfortable in an environment of 70°F with air moving at 0.33 feet/second, or roughly the insulation value of typical indoor clothing.

Closed-circuit SCBA. A recirculation-type SCBA in which the exhaled gas is rebreathed by the wearer after the carbon dioxide has been removed from the exhalation gas and the oxygen content within the system has been restored from sources such as compressed breathing gas, chemical oxygen, and liquid oxygen, or compressed gaseous oxygen.

Closure. A device or item of hardware used to secure open parts of protective clothing, such as zippers, snaps, and hook and dee rings. Closures may also include hook and loop fabric (e.g., Velcro). Positive closing closures are those which, when secured, remained secured to routine external forces.

Collar Lining. The part of collar fabric composite that is next to the skin when the collar is closed in the raised position.

Colorfastness. The ability of a material to retain the same color following exposure to a specific physical or environmental conditions.

Combustion. A chemical process of oxidation that occurs at a rate fast enough to produce heat and usually light in the form of either flames or glow.

Components. A general term used to describe all materials used in the construction of protective clothing including, but not limited to, thread, trim, bindings, zippers, buttons, and labels, but excluding textile fabrics, interlinings, and emblems.

Composite. The layer or combination of layers for a protective clothing item. For example, turnout clothing composites include the outer shell, moisture barrier, and thermal barrier.

Compressed Breathing Gas. Oxygen or a respirable gas mixture stored in a compressed state and supplied to the user in gaseous form.

Conduction. For thermal protection, refers to heat transfer through a material by direct contact with another material or surface.

Convection. For thermal protection, refers to heat transfer through a material by air transmission.

Coronal Plane. In describing the position of the helmet, the plane, perpendicular to the basic and mid-sagittal planes, that passes through the centers of the external ear openings.

Crocking. Transfer of material dye to other materials by physical contact.

Crown. The portion of the helmet that covers the head above the reference plane.

Crown Straps. That part of the suspension for the helmet that passes over the head.

Cut Resistance. The capacity of a material to prevent cut-through by a sharp-edged blade.

Demand SCBA. See “Negative Pressure SCBA.”

Dexterity. Ability of the wearer to use hands or manipulate objects.

Ear Covers. A flap of material or integral part of the helmet that provides heat and physical protection to the ears.

End-of-Service-Time Indicator. A warning device on an SCBA which warns the user that the end of the service time time of the SCBA is approaching.

Energy Absorbing System. A material, suspension system, or combination of the two, incorporated into the design of the helmet, to absorb impact energy.

Entry Clothing. Protective clothing that is designed to provide protection from conductive, convective, and radiant heat, and permit entry into flames.

Evaporative Heat Transfer. The process by which heat is removed from a surface by the evaporation of liquid. As applied to protective clothing, this measure refers to how easily bodily heat can be released from inside the clothing to the outside environment by the process of sweating which involves both permeation of air and transmission of water vapor as fluid for transferring this heat.

Fabric Component. Any single, or combination of, pliable, natural, or synthetic material(s) made by weaving, felting, forming, or knitting that is used to secure the backplate assembly to the SCBA wearer, including but not limited to, shoulder, waist, and chest straps.

Facepiece. The component(s) of an SCBA that covers, as a minimum, the wearer's nose, mouth, and eyes. Also known as a facemask.

Faceshield. An transparent shield situated on the protective helmet which provides protection for the face and supplements primary eye protection.

Field of Vision. The peripheral range of view for a wearer of protective clothing or equipment.

Fill. In textile fabrics, the direction of the material perpendicular to the direction in which it was machined or fabricated. Also known as the cross-machine direction for fabrics.

Flame Resistance. The property of a material to prevent, terminate, or inhibit combustion following application of a flaming or non-flaming source of ignition, with or without subsequent removal of the ignition source. Flame resistance can be an inherent property of the material, or it may be imparted by specific treatment.

Footwear. Boots or other items of protective clothing designed to cover the wearer's feet and ankles.

Garment. A item of protective clothing which covers the torso and limbs.

Garment Label. A label affixed to protective clothing by the manufacturer, containing general information, warning, care, maintenance, or similar data about the garment. This garment label is not a certification organization label or identifying mark.

Gauntlet. The circular, flared, or otherwise expanded part of the glove that extends beyond the opening of the glove body to cover the wrist areas. (See also "Wristlet.")

Glove Body. The part of the glove that extends from the tip of the fingers to 1 inch beyond the wrist crease.

Hardware. Nonfabric components of protective clothing, including those made of metal or plastic material Examples include rivets, snaps, buckles, and zippers.

Haze. Light which is scattered as a result of passing through a transparent object.

Headband. The portion of a suspension on a helmet that encircles the head.

Headform. A test device that conforms to the configuration of the human head used for testing helmets.

Heat Resistance. The property of a material to retain useful properties as measured during exposure of the material to a specified temperature and environment for a specified time.

Heat Stress.

Helmet. An item of protective clothing that is designed to protect the fire fighter's head from physical and thermal hazards. As required in NFPA 1972, helmets are also required to provide limited physical and thermal protection to the face and ears.

Home Laundering. A process by which textile products are washed, bleached, dried, and pressed by any conventional method designed for residential or non-professional use.

Horizontal Center Plane. In describing the position of the helmet, any plane passing through the helmet whose intersection with the helmet surface is equidistant from the top of the helmet at all points.

Human Tissue Burn Tolerance. In testing thermal protective clothing, the capacity to withstand the amount of thermal energy which causes a second degree bum in human tissue.

Impact Resistance. The capacity of a protective clothing item to resist deformation or breakage when struck by a large, heavy object.

Inherent Flame Resistance. As applied to textiles, flame resistance that is derived from an essential characteristic of the fiber or polymer from which the textile is made.

Insole. That part of the protective footwear next to the bottom of the foot designed to afford support and padding.

Interface Area. An area of the body not protected by a protective garment, helmet, gloves, footwear, or SCBA facepiece; the area where the protective garments and the helmet, gloves, footwear, or SCBA facepiece meet: i.e., the protective coat/helmet/SCBA facepiece area, the protective coat/glove area, and the protective trouser/footwear area.

Interface Component. Item(s) designed to provide limited protection to interface areas.

Interlining. Any textile that is intended for incorporation into any article of wearing apparel as a layer between the protective layers.

Knitted Fabric. A fabric structure produced by interlooping one or more ends of yarn or comparable material.

Ladder Shank. Reinforcement to the shank area of protective footwear designed to provide additional support to the instep when the wearer is standing on a ladder rung.

Light Transmission. The efficiency of material in allowing different wavelengths of light to pass through without reflection or absorption by the material.

Liner. A material layer inside of the outer shell. May include moisture barrier, thermal liner, or winter liner.

Luminous Intensity. A measurement used to determine the efficiency of retroreflective trim to be visible at different angles with respect to the illumination light source.

Manual. A functional mode in which the PASS/Alarm Signal is activated.

Melting. In testing thermal protective clothing, a material response to heat or flame as evidenced by softening and flowing of the fiber material.

Mid-Sagittal Plane. In describing the position of the helmet, the plane, perpendicular to the basic and coronal planes, that symmetrically bisects the head.

Model Weight. The basic weight of the helmet plus accessories for the specific model identified.

Moisture Barrier. That portion of the composite used in tie fighter protective clothing designed to prevent the transfer of liquid water from the environment to the thermal barrier.

Motion Detector. An integral portion of the PASS that senses movement, or alternatively, lack of movement, and activities the alarm signal under a specified sequence of events.

NIOSH/MSHA Certified. Tested and certified jointly by the National Institute for Occupational Safety and Health (NIOSH) of the U.S. Department of Health and Human Services and the Mine Safety and Health Administration (MSHA) of the U.S. Department of Labor, in accordance with the requirements of Title 30, Code of Federal Regulations, Part 11, Subpart H (30 CFR 11). For the NIOSH/MSHA certification to remain in effect, the SCBA must be used and maintained in the approved condition.

Nape Device. A device located on the helmet below the bitragion inion arc, used as an aid to helmet retention.

Off. A functional mode in which the PASS is deactivated.

Open-Circuit SCBA. An SCBA in which exhalation is vented to the atmosphere and not rebreathed. There are two types of open-circuit SCBA: negative pressure or demand type and the positive pressure or pressure demand type.

Outer Shell. That outside facing portion of the composite on protective clothing not including trim, hardware, reinforcing material, and wristlet material.

PASS. An acronym for Personal Alert Safety System.

Positive Pressure SCBA. An SCBA in which the pressure inside the facepiece, in relation to the pressure surrounding the outside of the facepiece is positive during both inhalation and exhalation, as tested by NIOSH in accordance with 30 CFR 11, Subpart H.

Preconditioning. To bring a material to a specified condition prior to testing. Preconditioning may include exposure of the material to specific temperatures and humidities, high heat, cold temperatures, or immersion in water.

Pressure Demand SCBA. See “Positive Pressure SCBA”.

Protective Clothing. Protective garments, configured as a coat and trousers or as a coverall, and interface components that are designed to provide protection to the wearer’s body.

Protective Coat. Protective garment designed and configured to provide thermal and physical protection to upper torso and arms, excluding the hands and head.

Protective Footwear. A boot that provides thermal and physical protection to the wearer’s foot and ankle.

Protective Garment. Protective coat, protective trouser, or protective coverall.

Protective Glove. An article of protective clothing with two, three, or five fingers, designed to provide limited thermal and physical protection to the hand and wrist during structural fire fighting or rescue operations.

Protective Hood. The interface component that provides limited thermal and physical protection to the protective coat/helmet/SCBA facepiece interface area.

Protective Toecap. Reinforcement to the toe area of protective footwear. Toecaps are designed to protect the toes from impact and compression.

Protective Trouser. Provides protection to lower torso and legs excluding the feet.

Proximity Clothing. Reflective protective clothing that is designed to provide protection against conductive, convective, and radiant heat.

Puncture Resistance. The capacity of a protective clothing material to withstand rupture by a pointed or conically shaped object.

Puncture-Resistant Device. Reinforcement to the bottom of protective footwear located between the sole with heel, and the insole, and designed to provide puncture resistance to the maximum area of the insole allowable by the footwear construction.

Radiant Heat. Heat which is emitted by one material and absorbed by another over a distance.

Rated Service Tie. The period of time, stated on the SCBA’s NIOSH/MSHA certification label, that the SCBA supplied air to the breathing machine when tested to 30 CFR 11.

Reference Plane. In describing the position of the helmet, the plane 60 mm (2.36 in.) above and parallel to the basic plane.

Retention System. The complete assembly of the helmet which consists of a chin strap, nape device, and suspension system by which the helmet is retained in position on the head.

Retroreflective. Descriptive of a material that reflects and returns a relatively high proportion of light in a direction close to the direction from which it came.

SCBA. See "Self-Contained Breathing Apparatus."

Seams. The attachment or junction of two textile materials through either sewing or taping the separate parts together. NFPA 1971 on protective clothing further defines three types of seams:

> **Major A Seams.** Outer shell seam assemblies where rupture could reduce the protection offered by the garment by exposing the moisture barrier, thermal barrier, the wearer's station/work uniform, other clothing, or skin.
>
> **Major B Seams.** Moisture barrier or thermal barrier seam assemblies where rupture could reduce the protection offered by the garment by exposing the next layer of the garment, the wearer's station/work uniform, other clothing, or skin.
>
> **Minor Seams.** Remaining seam assemblies that are not classified as Major A or Major B scams.

Seam Strength. The maximum resistance to junction breakage formed by stitching two or more planar structures, such as textiles fabrics.

Self-Contained Breathing Apparatus (SCBA). A respirator worn by the user which supplies a respirable atmosphere that is either carried in, or generated by, the apparatus and is independent of the ambient environment.

Service Time. See "Rated Service Time".

Sewn Seam. A series of stitches joining two or more separate plies of material(s) of planar structure, such as textile fabrics.

Shell. The outmost part of the helmet.

Sound Pressure Level. The measurement of loudness of a sound in decibels.

Station/Work Uniforms. Garments worn under protective clothing, including, but not limited to, pants, shirts, jackets, or coveralls, but excluding underwear and socks.

Suspension. An energy absorbing system on the helmet made up of headband and crown strap.

Sweatband. That part of a headband on the helmet, either integral or attached, that comes in contact with the wearer's forehead.

Tearing Strength. Also tearing resistance. The force required to either start or continue a tear in a fabric.

Tensile Strength. See “Breaking Strength”.

Tensile Testing Machine. An apparatus designed to impart, or transmit, force/extension, or stress/strain, to a material, and to measure the effect of the action.

Textile Fabric. A planar structure consisting of yarns or fibers.

Thermal Barrier. That portion of the composite designed to provide thermal protection.

Thermal Protective Performance. The rate of heat transfer through a protective clothing material from a combined convective and radiant heat source which produces a second degree burn on human tissue.

Thermal Shrinkage. The change in dimensions of a fabric specimen when exposed to heat.

Throat. The lowest portion of the boot closure that allows boot donning and doffing.

Top. The intersection between the mid-sagittal plane and the bitragion-coronal arc extended to the helmet surface.

Top Line. The top edge of the protective footwear which includes the tongue, gusset, quarter,

Tragion. A point in the depth of a notch just above the external opening of the car.

Trim. Retroreflective and fluorescent material attached to the outer shell for visibility ehancement. Retroreflective materials enhance night time visibility, and fluorescent materials improve daytime visibility

Upper. That part of the protective footwear including but not limited to, the toe, vamp, quarter, shaft, collar, and throat, and other than the sole with heel, puncture-resistant device, and insole.

Warp. In textile fabrics, the direction of the material parallel to the direction in which it was machined or fabricated. Also known as the machine direction for fabrics.

Wear Surface. On footwear, the bottom of the sole, including heel.

Winter Liner. An optional component layer designed to provide added insulation against cold.

Wristlet. The circular, close fitting part of the glove, usually made of knitted material, that extends beyond the opening of the glove body to cover the wrist area. (See also “Gauntlet”).

*U.S. Government Printing Office: 1993-722-661/80397